Use of Visual Representation in Natural Resource Management

Mariana Beatriz Cruz Chú

Doctor of Philosophy

University of Edinburgh

2008

Abstract

The increasing use of visual representation in natural resource management is signed as a promising tool for enhancing the communication with bidirectional flow of information among stakeholders. Some targets are the transfer of scientific knowledge to non-scientific groups and the study of perception that local communities have about their environment. Both of them have critical importance in developing countries. The objective of this thesis was to get further knowledge on some topics and concerns related to the use of photographic material as surrogates of natural grassland areas among shepherds and extension advisers. The thesis developed studies in two main grassland areas of Peru. The first study was carried out in Azangaro, Puno, in the Peruvian High Plateau. This study explored the reliability and validity of the use of visual material in performing assessments about common concepts used in grassland management by extension advisers, whose role in the chain of technology transfer is important in this area. The second area of study was the SAIS Pachacutec, which involves a significant grassland area in Junin, located in the central mountain region of Peru. Two main research topics were investigated in this area. First, there were comparisons in the use of different techniques (random and participatory approaches) for visual sampling in rangelands. And second, the use of photographic material combined with Q methodology was explored for the elicitation of environmental perceptions among shepherds and local administrations. Implications of results for future use of visual representation in natural resource management are discussed.

Declaration

I declare that I composed this thesis, that the work contained herein is my own except where explicitly stated otherwise in the text, and that this work has not been submitted for any other degree or professional qualification.

Mariana B. Cruz Chú, 2008.

Acknowledgements

I am greatly grateful to my supervisor, Dr. Mario Herrero, for his invaluable support and aid during the course of my PhD studies. I am also deeply indebted to Dr. Roberto Quiroz at the International Potato Center, for his help, feedback and encouragement throughout the development of this research. I would like to thank Dr. Erick McKenzie and Dr. James Wright for their suggestions and comments on the topics of their expertise.

My thesis was supported financially by the International Potato Center and the System Livestock Program, within the framework of the Virtual Laboratory on Systems Analysis in mixed Crop-Livestock Systems. I am hugely grateful to these institutions for making possible my PhD studies and the development of this research.

Especially, I would like to thank all the team of the Natural Resource Management Division at the International Potato Center for their support and friendship along the way. I would like to thank Percy Zorogastúa, Alberto García, Carolina Barreda, Diana Torres, Perla Chávez, Haline Heidinger, Cynthia Gómez, Jorge Del Carpio and Guido Yactayo for their untiring help and enthusiasm as well as for facing together the many difficulties we had in the field trips.

I am very grateful to the group of advisers in Azangaro and the population and researchers in the SAIS Pachacutec who collaborated with the research. Also, I would like to thank the administration of the SAIS Pachacutec for providing the facilities in this area and making possible this work as well as the professors of grassland management in the Universidad Nacional Agraria La Molina for their suggestions at the initial part of this research.

Finally, I would like to thank my family for being guardian of my sanity. I own a special debt to my brother Eduardo for his comments and my mother, Carlos and David for their support and patience.

Dedicated to my mother and the memory of my father.

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Chapter 1

Introduction

This thesis presents a study on the use of visual material as surrogates of natural environments in topics of natural resource management. The thesis explores the use of visual material by farmers and extension advisers in developing countries. This chapter serves as an introduction to the subject of this thesis. In section 1.1 a brief overview of the motivation of the present research is presented. In section 1.2 a chapter by chapter outline of the thesis is given.

1.1. Visual Representation and Natural Resource Management

Visual representation (such as photographs, photosimulations, 3D modelling) in natural resource management (NRM) has being used with different purposes for a long time. Human capacity to process the visual information in an intuitive way (Trumbo, 1999) as well as the fact that almost all the decisions taken in activities of NRM require visual information (White, 1992) are some of the reasons why visual representations have been promoted in this context. Natural resource scientists make use of such representations for trying to get a better understanding of their data, for communication of findings and dissemination of knowledge, for interacting with stakeholders and for getting further knowledge of human behaviours (Orland, 1992), among others.

In turn, there is a constant debate about problems of communication between the different actors in NRM (e.g. between researchers and farmers) (Ball, 2002). Some authors argue that while one constraint of conventional research has been frequently the limited contact that researchers used to have with farmers (e.g. livestock researchers with resource-poor livestock-keepers) (Conroy, 2005), the inclusion of local stakeholders in the research process is essential since NRM depends to a large extent on decision making processes carried out by land users at farm and parcel level (Bussink, 2003). Moreover, farmers use to own a rich base of local knowledge about their environment and so local knowledge may contribute to provide important information about local conditions. For example, Patrick (2002), studying the use of satellite imagery for management of ephemeral surface water, found that visual interpretation of images by local people was more effective for finding suitable areas for water harvesting than the interpretation made by the researcher in a computer-based analyses of spectral data.

In this regard, visual representations are more frequently promoted in NRM not only as just visual descriptive aids (e.g. Milton *et al.*, 1998; Ottmar *et al.*, 2004) but also as support tools for enhancing public involvement in participatory research (e.g. Al-Kodmany, 1999). The use of visual representation for improving the communication of information has been the subject of several studies (e.g. Al-Kodmany, 1999; Al-Kodmany, 2002; Orland *et al.*, 2001) to the point of having become a field of research *per se*. Its use is even promoted by some researchers as a 'common currency', which can be used in bi-directional communication processes where different profile groups are involved (e.g. researchers and public) (Orland *et al.*, 2001). Other researchers in planning and design activities argue that visualizations constitute a key element since it is sometimes the only language that participants can relate (Al-Kodmany, 1999; King *et al.*, 1989).

Moreover, visual representation is frequently used as a surrogate of real environments for the study of environmental perception since its related costs are lower and in general more affordable than the possibility to transport the study's participants to the area of interest. The visual representation makes it possible to recreate some hypothetical scenarios which do not exist in the real environment but which could be of interest in some research topics (e.g. the visual impact assessment of a project or the output scenario of a simulation model run under specific parameters).

In this sense, the use of visual representation in natural resource management is considered by some researchers as a powerful tool for interacting and improving the understanding of the target user (the stakeholder) as well as a way of getting knowledge from the different human groups which are involved in the decision making process (Orland *et al.* 2001; Tress and Tress, 2003). As a result, managers are being exposed to technical advances in visual representation. The development of the area of visualization and its subsequent applications in the development of realistic and non-realistic computer generated images are the cause of the quandary that many resource managers have about the use of such technology (White, 1992).

However, the access to new technologies of visual representation is still limited in poor areas. There is still a technology break in rural areas of developing countries due to economic restrictions and the technical knowledge required for the use of new technologies of visualization. Asare *et al.* (2003) discuss that while in developed areas, the support for the use of computer graphics applications as an important component for the development of enterprises of any importance has been established over the last 20 years, in developing countries the support for the implementation of this type of technology is still limited. The 1987 report on visualization in scientific computing (McCormick *et al.*, 1987) is one of the works which contributed to the change of perception in the use of visual representation as "nice pictures but only marginal to the success of other fields" to the actual use as part of the development (Asare *et al.*, 2003).

On the other hand, in poor areas, the use of technologies of visual representation such as computer graphics is still limited by the prohibitive costs to local population of rural areas. As it is the case in Information Communication Technologies (ICTs), difficulties related to infrastructure, educational development and training, isolation from the new approaches, financial and political constraints as well as limited support, and social and cultural challenges are the major problems in the implementation of computer-based technologies (Asare *et al.* 2003; Pade *et al.* 2006). As a result, the use of more affordable options, such as photographs, drawings and charts (e.g. Waller *et al.*, 1998) are often used in these areas for the presentation of information to local stakeholders. In this regard, some authors argue that photographs are suitable tools rather than large-scale visualizations or abstract representations for the communication of an idea to stakeholders since photographic material requires little interpretation by the stakeholder due to its realism and details (Al-Kodmany, 1999; Orland *et al.*, 2001; Tress and Tress, 2003). Despite restrictions in rural areas of developing countries, the utility of visual representation such as photographs, is considered a promising medium to interact with local groups of stakeholders (i.e. farmers).

However, in spite of the use of visual material has had in different fields of NRM and the many claims about its applications across the literature, the verification of some basic aspects of its use by managers, such as its validity and reliability, remains an open research field in NRM (Palmer and Hoffman, 2001; Sheppard, 2001). Moreover, despite the common use of visual material in information transfer to local stakeholders, limited research has been done to get further knowledge about the visual literacy of local managers such as farmers or livestock-keepers.

In this sense, the goal of this research was to get further knowledge on the use of visual representation in natural resource management, especially in the conditions presented in developing countries. This work was developed within the framework of the project Virtual Laboratory on Systems Analysis in mixed Crop-Livestock Systems, supported by the System Livestock Program and the International Potato Center and partners. For this reason, the major part of the present work was also subscribed to the topic of grazing management activities, where a lot of the decisions of farmers are based on visual information. Two main study areas cover this work; both of them were located in high grassland areas of Peru (above 3000 m). The main economic activity was related to the livestock and grazing management and so the welfare of their local population depended mainly on such activity. Two main target groups of stakeholders were involved in this research, the shepherds and the extension advisers whose function plays a critical role on the knowledge transfer in these areas.

1.2. Outline of the thesis

Three main subjects debated across the literature were subject of research in this thesis: 1) the validity and reliability of visual representation (photographic material in this case), 2) its representativeness and 3) its applicability in the perception research of these target human groups. The hypothesis of the present work was that the application of visual material constituted a valid, reliable and useful tool for being used in such context. The research was designed as a series of chapters which have been prepared for publication.

1.2.1. Chapter 2 – The use of visual representations in natural resource management: an open research field

Drawing on several applications of visual material in different fields of NRM, chapter 2 presents a review of open research areas related to the use of visual representations by local managers as well as potential problems in the development of visual aids. Some questions such as 'why to use visual representations in NRM?' or 'how to produce more realistic visual representations of natural resources?' have received some attention across the literature (e.g. Ervin and Hasbrouck, 2001; Hokkanen, 1999; Muhar, 2001). However, in spite of the many claims and the common use of different types of visual material in NRM, there are several aspects of its application, which still needs further research. As far as the literature review allowed discerning, little knowledge about the verification of some claims in the validity, representativeness and effectiveness of such tools is still lacking for its use among farmers. Despite the advances in visualization field, "are further improvements in technology as urgently needed as further improvements in our knowledge and control of how such systems are used?" (page 13, Sheppard, 2001). In this chapter, it is discussed that even some visual formats commonly used in rural areas (e.g. photographic material) (Gómez-Limón and Fernández, 1999; Milton *et al.*,1998; National Research Council U.S., 1962; Ottmar *et al.*, 2004) present some potential problems that can alter the validity and effectiveness of its use. Across this literature review it is recognized that among the areas which need further research are included for example, the research questions: are visual representations valid and reliable tools for its use by local managers in NRM? What approach to use for the selection of visual material which is going to be viewed by local population? Are the components which controls the visual attention in these tools the same across the target group of viewers?

These research questions are the focus of the next parts of the research although some additional concerns are also reviewed in this chapter. It is proposed that even if the use of visual material has a long tradition in NRM, there still persist knowledge gaps about its use which needs further research.

1.2.2. Chapter 3 – Exploring the validity of visual representation for grassland assessment

Having as framework the Virtual Laboratory on Systems Analysis in mixed Crop-Livestock Systems, the following chapters of the work were mainly carried out in a rangeland context with the objective to get further knowledge of some open research areas that were exposed in chapter 2. Livestock's contributions to the livelihood of farmers are especially important for the resource-poor households. Conroy (2005) states the majority of households in rural areas of developing countries own some kind of livestock. So the contribution of livestock to the livelihoods of people living in these areas plays an essential role. For example, as a source of cash income, liquid asset, inputs to crop production, utilization by poor of land owned by other, diversification of risk/buffer to crop yields, source of food and cultural values, among others (Conroy, 2005). As a result, different approaches have been used for rise livestock productivity as well as the sustainable support of rangelands (e.g Conroy, 2005; Heffernan *et al.*, 2004; among others). In this case, livestock research has made use of visual material for information transfer among local stakeholders in order to improve the communication of research findings and aid tools in rangeland assessment (e.g. Milton *et al.* 1998; Ottmar *et al.*, 1998; Ottmar *et al.*, 2004; Wright *et al.*, 2002).

An important assumption of the use of visual representations in this context and in NRM in general is that these representations are valid and reliable tools. That is that the viewers' responses to visual representations provide valid indications of perceptions and judgments made in response to direct experience with the landscape conditions nominally represented (Daniel and Meitner, 2001). In this regard, there is the assumption that visual representation can be used as valid support tools when the rangeland assessments are required by land users. However, the validity and reliability (i.e. consistency of the assessments among evaluators) of visual representations in a rangeland context have received little attention by the researchers. In spite of several studies which report the validity of visual representations (e.g. photographs) as surrogates of the real environments, these studies have been performed in different topics (e.g. scenic beauty) and little research has been done in the validity of visual material for decisions taken by local land users in rangeland context. Moreover, little research can be found about the validity of the use of visual representations in poor rural areas such as the ones found in the rangeland of developing countries.

Chapter 3 gives some insight in this research topic. For this, a study was carried out in a grassland area of Puno, Peru. Through the use of photographic material, it was explored the validity and reliability of the use of visual material by extension advisers working in the study area. In addition, although the use of software for the production of computer-based visual simulations (e.g. 3DNature) in the study area is still not available due to costs and the needed infrastructure, the study presented in

Chapter 3 also explores the level of realism-abstraction which can be included in valid computer-based representations in this rangeland context for future use.

1.2.3. Chapter 4 – Comparing techniques of visual sampling in rangelands: Random versus participatory techniques

Following the open research questions identified in Chapter 2, one related topic that relatively little attention has obtained from researchers and practitioners is the representativeness of such visual material. Whilst there are multiple approaches for obtaining samples of the ecological or topological landscape, little research work is found for obtaining samples of the seen landscape (visual sampling) (Hull IV and Revell, 1989). There are an infinite number of scenes to be photographed across an area. The selection of each scene to be included in the visual sample is based not only on the selection of the place from where to take the photograph (vantage point) but also what to 'see' from that place. This fact adds a critical element when the visual sample is used in tasks of visual assessment: the photographs have to reflect not only a representative sample of the properties of physical environment but also the visible elements that determine how people view this physical environment (Hull IV and Revell, 1989). In this sense, Chapter 4 provides an exploratory study for comparing three methods for visual sampling a grassland area in Junin, Peru. The study has the objective to contrast the visual elements taken by the selected methods in order to use the obtained visual sample in a subsequent research which involves the study of perceptual assessment by local land users (shepherds) in the study area (Chapter 5). In this regard, the inclusion of visible elements which could be relevant for the perceptual judgement is an important component for the success of the visual sampling.

1.2.4. Chapter 5 – Use of visual material for eliciting shepherds' perceptions of grassland in Highland Peru

Following the study of chapter 4, chapter 5 provides a study carried out in the grassland area of Junin in order to get further knowledge about which are the visible elements that are important for the perceptual judgement of local land users. In this regard, the study in chapter 5 extends the work presented in chapter 4 through the exploration of the elements of the environment that local land users 'see' in the photographs (visual sample).

In the field livestock participatory research, the use of visual aids has been promoted as tools to enhance the interaction with farmers. For instance, the use of visual material has been suggested as aid tools for the elicitation of information about livestock production and types of livestock that each household have (Conroy, 2005). In contrast, the scope of the work presented in chapter 5 addresses the use of photographic material for studying the perception that local land users (shepherds) have about their grasslands. This study explores the open research questions: what local land users (shepherds) 'see' for judging their grasslands? Are there perceptual differences across the local population? If so, which are the visible elements that are relevant for the different perceptions? How are the responses using a visual questionnaire compared to the responses obtained by other type of questionnaires (e.g. verbal/written questionnaires)? For this, a Q methodology is applied with the use of visual material (visual sample) so the work in chapter 5 also provides an exploration of this methodology promoted in different areas of perceptual research. Q methodology, developed by Stephenson (1953), is a research method applied in the study of people's subjectivity. Although it is based on factor analysis, the difference with the 'R method' (where the correlations are between variables) is that in Q method, the correlations are between the subjects and across a sample of variables (in this case, the photographs). In its more commonly used application, the Q methodology makes use of the presentation of written statements (Brown, 1980) but other types of material have also been reported in different research areas, e.g. Fairweather and Swaffield (2001), Gabr (2004), and Swaffield and Fairweather

(1996). As far as the literature review allowed discerning, Q methodology with visual material had not been previously applied for rangeland assessment in a context of developing areas. The work in chapter 5 shows that the methodology provides some advantages when the research involves some restrictions (e.g. limited time of interview, interest of the participant by the research, among others).

1.2.5. Chapter 6

Finally, Chapter 6 summarizes the discussion, contributions and describes directions for future research. Implications for rangeland research and potential significance to the use of other types of visual formats are provided.

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Chapter 2

The use of visual representations in natural resource management: an open research field

2.1. Abstract

Visual representations are frequently promoted as tools for enhancing the bi-directional communication between and within different stakeholder groups in natural resource management (NRM). Despite several claims have been made about the effectiveness of visual representations for communication with local stakeholders, the verification of such claims is limited and needs further research. This paper reviews some concerns about the application of visual representations in NRM and identifies some standing research questions, which are relevant for the improvement of participatory methods that use visual aids. NRM generally depends on decisions made by the land-user at farm level. Therefore, this review is centered on the use of visual representation tools by direct natural resource managers (e.g. farmers and pastoralists). However, it also pays some attention to the current use of the tools by researchers. The review identifies research gaps in the use of visual representations as tools for enhancing discovery and information transfer and discusses the use of support manuals for rangeland monitoring, the representation of different scenarios and elicitation of land-user perceptions. It is proposed that further research in the identified areas could enhance the effectiveness of visual tools and can give better insight into recurrent questions as to whether visual representations are tools that in effect narrow the communication gap between researchers and farmers.

2.2. Introduction

During the last decades, there has been a substantial development of decision support tools in agriculture, such as crop and livestock simulation models (e.g. Day, 2001; Herrero *et al.*, 2007; Jones *et al.*, 1998; McCown *et al.*, 1996; Pokovai and Kovacs, 2003; Sinclair and Seligman, 1996; Thornton and Herrero, 2001). These tools have increasingly been promoted as useful research and decision support aids not only for scientists but also for agricultural managers. By facilitating the transfer of scientific knowledge from researchers to managers (Parker and Sinclair, 2001) these tools assist the latter in making more effective decisions and improving agricultural productivity. Ruttan (2002) argues that substantial increases in scientific and technical knowledge will be necessary, particularly in developing countries, for agricultural production to keep pace with increased food demand related to population growth. He argues that in the poorest countries, the transition from a natural resource-based to a science-based agriculture, required to increase crop and animal production, has been delayed as compared with the evolution of agriculture in developed countries. Agricultural production and productivity in developing countries is below their potential due to a number of constraints and the failure of conventional research. Indeed, paradigms of agricultural research, which have been successful in developed countries, have not been effective in less developed areas because they have often failed to recognize the particular circumstances of small farmers (Conroy, 2005; Roeleveld and van den Broek, 1996).

A critical requirement for the attainment of sustainable agriculture is the active participation of all different actors, including farmers and extension workers, during the research for new understanding and solutions (Pretty, 1995). Participation of stakeholders not only increases the identification of priority needs but also increases the livelihood of technology adoption (Conroy, 2005; Heffernan *et al.*, 2004). Besides technology adoption, there is also a concern among researchers about the low degree of adoption of support tools by extension workers and farmers in agricultural practice. This so-called 'problem of implementation' (McCown 2002a;

McCown 2002b) has originated a continuous discussion about the impact of the investment related to the development of these tools (Leeuwis, 1993; McCown, 2002a; Woods *et al.*, 1993). Some actions have been suggested in order to solve this problem (e.g. extension activities for enhancing the use of information technologies among farmers, the coordination and standardization of systems and databases among scientific groups and the implementation of more research on decision-making processes for the identification of 'real information needs' of different stakeholders) (Leeuwis, 1993). As there is still a need of an effective communication interface among scientists and policy makers (Grant, 1998), it has been suggested that technology should be packaged in more 'user friendly' tools (Hofstede, 1992) since many support devices are still inadequate for providing an efficient way to communicate with public outside the agricultural scientist groups (Cox, 1996). Some suggestions include the use of a user-centered design (Lynch *et al.*, 2000; Parker and Sinclair, 2001) and the involvement of the user during the implementation process of the tool. Nevertheless, one of the major problems that researchers have to overcome is to accomplish an effective 'user-participation', mainly because the factors affecting the relationship between the user-participation and a successful process of adoption are not completely clear (Cavaye, 1995; Leeuwis, 1993).

Active participation of managers seems to be a key issue for the success of technology development, adoption and impact brought about by continuous access to new technology (Parker and Sinclair, 2001) but further research in the use of new platforms of decision support and new forms of participation which could better engage stakeholder's interests are still required (Pretty, 1995). For instance, studies carried in South Asia have shown that farmer participation not only improves the collection of information (e.g. by cross-checking information by farmers) but also increases the identification of the farmer with the research activity (Campilan *et al.*, 2006). In addition, studies carried out in Africa have shown that the involvement of the farmers in the process of technology development indeed produces more suitable practices for solving local problems (Reij and Waters-Bayer, 2001). Farmer innovation programmes contributes to the expansion of the social capital by sharing knowledge and products with other farmers, encouraging the recognition of innovators within the community and motivating the participation of farmers for innovating on their own initiative. As a result, the innovation process is promoted instead of just only the innovations (Reij and Waters-Bayer, 2001). Nevertheless, one weakness of participatory methods is that farmers' response decreases in the course of time. Keeping the interest of farmers is a difficult task due to 'participation fatigue' (Campilan *et al.*, 2006). In this context, the use of visual methods and the application of advances in visual representation of natural resources (Ervin, 2001) constitute an open and exciting field of research with promising contributions for enhancing the bi-directional flow of information between and within different stakeholder groups and for bridging some communication gaps found in participatory research methods and natural resource management (NRM).

The purpose of this paper is to review some open research questions about the increasing use of visual representations in NRM in the referred context. First, an initial discussion about the potential user of visual representations in NRM is presented. Next, some uses of visual representation for improving the processes of communication and understanding in NRM are reviewed and related open research areas are analyzed. Finally, some additional concerns related to the use of visual representations that matter to NRM are discussed.

2.3. The users of visual representation in NRM

The Agenda 21 of the United Nations Conference of Environment and Development (UNCEP) in 1992 states "In sustainable development, everyone is a user and provider of information considered in the broad sense. That includes data, information, appropriately packaged experience and knowledge. The need for information arises at all levels, from that of senior decision makers at the national and international levels to the grass-roots and individual levels" (UNCED, 1992, Section IV, Part 40.1). Nonetheless, specificity is required and 'everyone' should not be targeted as users when a tool is developed for decision-making support in NRM. However, the recognition that an effective communication among the different relevant stakeholders is a requirement for the development of a given tool oriented to a particular user (Ramírez, 1998) makes the identification of those relevant stakeholders a difficult task due to the diverse profile of the stakeholders to be of the implicated. On the other hand, the identification of the particular user is also difficult, as the decision maker who takes the critical decisions for farm management is not always clearly recognized among the target audience for the technology transfer activities. For instance, Solano *et al.* (2001) reported in a study of the decision making process of Costa Rican dairy farmers, that the decision making unit comprised a combination of actors while the extension and training activities was always targeted to just one of the actors participating in the decision making process. This is also the case of farming systems in the Andes (Ravnborg and Westermann, 2002), where decisions are made both at the household and community levels.

White (1992) stated that it is difficult to imagine any significant NRM activity that does not rely to some extent on visual representations. In this regard, despite the widely held view that visual representation could be used as a 'common coin or common language' for increasing communication among different groups (Al-Kodmany, 1999; Al-Kodmany, 2002; Orland *et al.*, 2001) and hence as a tool to improve the communication for knowledge transfer, it has also been suggested that visualization is sometimes seen as just the 'icing on the cake' during the development of applications for supporting NRM (Anonymous, 1992). Three main reasons could be related to the limited function of visual representation in science communication (Trumbo, 1999). The first one is the possible intrinsic limitation of the visual media related to its social science communicative value (Ruby, 1975). "One picture is worth a thousand words, said an ancient Chinese; but it may take 10,000 words to validate it" (page 1245, Hardin, 1968). In this sense, it is argued that stand-alone visual representations, without printed or spoken words, may not transmit the complete concept to be communicated. Secondly, another reason to the limited function of visual representation is related to our own limitations and our culturally derived attitudes toward visual media instead of the visual media limitations (Ruby, 1975). It is argued that the communication through spoken/written mode has been used for thousands of years by the human beings. In contrast, technology to produce visual media is recent and the scientific research about its communicative potential is under study (Worth, 1966). Last, but not least, the third reason to the limited function of visual representations in science communication is related to the fact that training in visual communication is not as frequent as it is in written/spoken communication (Ruby, 1975). It has been stated that visual literacy has only received attention due to the influence of television on behaviour and learning in children (Seels, 1994) and in addition, visual literacy within the traditional education system has not been a priority (Trumbo, 1999). In this regard, it has been suggested that more training to scientists in communication is necessary for transmitting scientific research to the public more effectively (e.g. how to present new knowledge verbally and graphically) (Chappell and Hartz, 1998).

Despite this, the use of visual material for NRM is not a new concept. Some current uses are discussed in the next sections.

2.4. Some applications of visual representation in NRM

Visual stimuli are key components for the understanding of information. The magnitude of visual processing and extracting information from visual stimuli by the human brain is far greater compared to verbal processing (Graber, 1996) despite the existence of individual differences in such tasks (Childers *et al.*, 1985). The recognized advantages that visual information has in cognitive processing in the human brain compared to other types of information such as verbal or written (Tufte, 1983) suggests its potential use in increasing environmental awareness and influencing behaviour (Sheppard, 2006). In this sense, some researchers promote the use of visual representation of complex information as an intuitive way to greatly increase the comprehension of the data and for overcoming obstacles imposed by social and educational condition as well as language in the communication processes

(Al-Kodmany, 2002; Gooding, 2004; Heming, 1996; Lewis and Sheppard, 2006; Paar, 2006). As a result, visual representations have a long tradition in NRM, from the use of drawings, maps and sketches (Tufte, 1997) to the use of computerized visualization tools for creating realistic images of landscapes and its components (Ervin, 2001). Its use can be assessed according to the viewers of such representations.

The remaining sections of this paper are oriented to review some research gaps in the use of visual representations by local managers (e.g. land-users), making also some reference to the current use by researchers.

2.4.1. Discovery

Visual representation and its contribution in the innovation processes are mainly related in the literature to the process of visual thinking and its application by scientists or practitioners (e.g. Gooding, 2004; Trumbo, 1999; Trumbo, 2000). Among researchers, one of the frequent uses of visual representation has been as a tool for enhancing the scientist's ability to acquire knowledge and share and transfer the information to other scientists (Lynch, 1985; Trumbo, 1999). It has been seen as a key tool for improving the understanding in scientific reasoning, creative thought and discovery. In this regard, visual representation contributes to move forward science and to improve the process of discovery (Trumbo, 1999) because it is related to the arguably key component of creativity: the analogical thinking (Bonnardel, 2000; Hargittai and Hargittai, 1994; Gasser, 1999; Goel, 1997; Messaris, 1998; Mitchell, 1993; Ward, 2004). It has been argued that unlike the way of processing verbal language, visual representations are based on analogical thinking (Messaris, 1994; Messaris, 1998) and this raises the value of images' role in creative thought. As an example, Messaris (1998) points out that a classic illustration of this is the reasoning that Friedrich von Kekule followed in the 19th century when he discovered the structure of the benzene molecule. After unsuccessful long time of work trying to solve the difficulties presented by incongruent facts in the initially proposed structure (six carbon and six hydrogen atoms placed in a row), he found the solution inspired by a dream where he saw the form of a snake taking hold of its tail. By analogy with this image and after reasoning the implications, he proposed that the structure of the benzene molecule was based on atoms placed in a circle, which was confirmed by subsequent research. Analogical thinking of visual representation is related not only with realistic representation but also with more abstract visual representation such as the graphic displays (i.e. bar graphs, charts, maps) of quantitative information (Messaris, 1998; Tufte, 1997). In this case, an analogy is created between the graphic displays and the related physical quantities.

On the other hand, among natural resource managers such as land-users (e.g. farmers, pastoralists), the potential use of different types of visual representation (e.g. photographs, diagrams or more sophisticated tools such as virtual environments) for creative thought is still not well documented. Although it is known that their daily chores are mainly based on decisions that rely on visual stimuli (e.g. visual assessment of rangeland conditions) (e.g. Dougill and Reed, 2005; Reed and Dougill, 2002), the knowledge of how the use of visual representations could improve the processes of discovery and innovation by land-users is scanty.

There is some evidence on the use of visual media that the analogical link of images differs according to cultural values (Piamonte *et al.*, 2001; Radley and Kennedy, 1997). Indeed, visual material (e.g. photographs) has often been used for studying preferences among different group profiles, e.g. livestock farmers, officers of the public environmental administration and recreationists (Gómez-Limón and Fernández, 1999). Consequently, it might be not surprising that the visual literacy of farmers differs to the one of the authors (i.e. researchers) of visual aids included in the tools designed for technology transfer (e.g. bulletins, guidebooks, etc). However, relatively little is reported about the level of adoption of visual aids designed by external agents to the community as sources of information and even less, its contribution to enhance farmer innovation and discovery.

2.4.2. Informative tools

Al-Kodmany (2002), reviewing the visualization tools and methods in community planning, points out that "the conversion of abstract data into imagery greatly reduces the risk of confusion while honouring the inherent human preference for visual information. Communication of ideas is as important as the information itself" (page 190, Al-Kodmany, 2002). Indeed, the information to be communicated is meaningless if the stakeholder cannot understand what is being presented. For example, during the study about efficiency of Environmental Impact Statements (EIS), which disclose the impacts of a project in the environment, Sullivan *et al.* (1997) found that the application of incomplete forms to transmit information such as inaccessible EIS reduces the understanding of the proposed project. Consequently, there is a reduction of public participation in the relevant project as well as an increase of public's misunderstandings and misinterpretations. Moreover, participants may search for indirect sources of information and not the direct viewpoint of the agency that is proposing the project. Sullivan *et al.* (1997) showed that EIS along with photosimulations (pictures of scenarios created by computer) outperformed the understanding acquired of original EIS without any visual representation.

Likewise, the application of visual representations in decision-making processes that involve planners, researchers, stakeholders and laypeople, is promoted as a powerful tool for showing complex information, improving the communication process and identifying stakeholder interests (Orland *et al.* 2001; Tress and Tress, 2003). Moreover, some researchers argued that the use of visual material increases the engagement of the manager (e.g. livestock-keepers) in the research, which is a difficult task to achieve with other methods when high levels of illiteracy are found (e.g. among women) (Conroy, 2005).

Despite all these arguments and the often use of visual aids (e.g. leaflets, brochures, photographs, posters, multimedia, video) as support material for the dissemination of information (Chirwa *et al.*, 2006; Heong *et al.*, 1998; Whitaker, 1993; Wijekoon and Newton, 1998), there are few studies which compare the effectiveness of different types of information formats for knowledge-dissemination among farmers. For instance, several studies report the application of different methods (from handouts to videoconferences) for information transfer about mastitis in dairy cattle among farmers (Karimuribo *et al.*, 2006; Peters *et al.* 1986). However, the comparison of different methods in order to contrast its effectiveness and its cost still needs further research. Bell *et al.* (2005) comparing different methods for training Tanzanian smallholder farmers about mastitis in their dairy cattle, found that visual methods increase the success of knowledge transfer, i.e. the method which transmitted information based only on verbal form (village meetings) were less effective than the ones which included some type of visual information (i.e. village meeting and video, diagrammatic handout, village meeting and diagrammatic handout and village meeting, video and diagrammatic handout). Nevertheless, they also reported that among the methods with visual aids, there was no benefit over the 'diagrammatic handout' method in isolation. That is, the use of methods which required more effort in logistics and expenses produced positive knowledge-dissemination outputs but did not increase the effectiveness of the transfer of information compared to more simple and often used paper-based forms.

In spite of the increasing use of visual representations for enhancing technology transfer, the scientific literature that reports and compares the efficiency of the use of visual material, is still limited. There is a research need to get further knowledge of the real impact of the incorporation of visual representations in NRM and its use among farmers. On the other hand, it could be that, as Sheppard (2001) states, the practitioners know quite well what the effectiveness of their own simulations is, and that is why they use them: it is just the scientific knowledge that is lacking.

2.4.3. Support Manuals and Sustainability Indicators

Different approaches have been used by scientists for the monitoring of natural resources (e.g. in rangeland assessment: Bosch and Booysen, 1992; Du Toit, 1995; Stokes and Yeaton, 1994). However, these methods are time consuming, complex or too expensive for the small-scale farmers (Milton *et al.*, 1998; Reij and Waters-Bayer, 2001). In this regard, visual representations have been promoted as useful tools for helping in the task of natural resource assessment and monitoring (e.g. National Research Council U.S., 1962). For instance, Milton *et al.* (1998) proposed a guide based on more than 200 photographs, maps and diagrams with the objective to facilitate the rangeland health assessment in arid Karoo shrublands. Designed for medium – to large- scale ranchers as target group, their purpose was to develop a 'quick, easy, interesting and effective' guide that might encourage self-learning. More recently, Ottmar *et al.* (2004) have also generated a photo series for quantifying Cerrado Fuels in Central Brazil which could serve to managers and scientists for describing woody material, vegetation, and stand conditions in comparable areas. For this, the researchers included wide-angle and stereo-pair photographs for showing each selected site and complemented with information on vegetation structure and composition as well as living and dead fuels. The stereo-pair photograph included for each site originates a three-dimensional image, which enhances the viewer's appraisal of natural fuel, vegetation and stand structure. In this regard, the development of such guides has the objective to produce a tool which could help in the 'sustainable' use of natural resources through empowering land-users to assess the condition and trend of their rangelands, promoting the engagement of the land-users with such work, informing land users of findings and encouraging further discussion about natural resource health (Milton *et al.*, 1998).

However, despite the common use of the term 'sustainable' in development initiatives (Lele, 1991), putting in practice it's monitoring is not an easy task. One approach for this has been the development of sustainability indicators. Their use has become frequent by many governments, international aid agencies and authors of research papers and participants of conferences (Bell and Morse, 1999; Lele, 1991) in spite of the fact that the use of simple indicators for summarising the complexity of some dimensions proposed in sustainability frameworks can be viewed as a dangerous simplification (Bell and Morse, 1999). The development of such indicators is the subject of a wide debate among the scientific community (e.g. Bell and Morse, 1999; Bell and Morse, 2001; Bell, S., Morse, S. 2003; Dougill and Reed, 2005; Pound *et al.*, 2003; Reed *et al.*, 2006; Rigby *et al.*, 2000; Stocking and Murnaghan, 2001). Indeed, part of the debate still focuses on basic questions such as who may be the target user of such indicators, why these users may want to use them and how the provided information will be used (Bell and Morse, 2001; Rigby *et al.*, 2000). Despite the long research effort, the limited use of the sustainability indicators by managers on decision making and setting of policy has generated an active debate among researchers (Bell and Morse, 2001; Brugmann, 1997; Pinfield, 1996; Rigby *et al.*, 2000). Bell and Morse (2001) argue that this problem of low adoption is due to the fact that most of the sustainability indicators developed by researchers are based on frameworks which tend to be more 'quantitative and explicit' while land users tend to manage information in a more 'qualitative and implicit' way. As a result, some researchers are proposing the inclusion of the active participation of stakeholders as an essential component for the development of such indicators at every stage of the research process (Brugmann, 1997; Dougill and Reed, 2005; Pinfield, 1996).

In approaches mentioned initially for using visual representation in monitoring, a top-down ('expert-driven') process is generally used. That is, the researcher selects the information to be included in the support guides for monitoring, e.g. sites, supplementary data (e.g. biomass, vegetation composition) and visual samples of the site of interest (e.g. taking one or more photographs) (National Research Council U.S., 1962; Milton *et al.*, 1998; Ottmar *et al.*, 2004). Some input from potential users can be requested to test and propose changes to the suggested guide before a revised version is finally published for its use (Milton *et al.*, 1998). In contrast, approaches that include community involvement from the first stages of the project, to develop monitoring processes which can be more accessible to land-users, promote stakeholder interest in sharing local knowledge with external sources to the community (e.g. researchers and extension officers) and increase the adoption of the proposed monitoring process. Stuart-Hill *et al.* (2005) reported a joint work among government, national non-governmental organizations and rural communities in Namibia for involving the communities in the monitoring of their conservancy. A main feature of their work was called the Event Book System, which was different to previous approaches due to the fact that the communities were who decided what to monitor and provided the information for undertaking the monitoring, whereas scientists only facilitated the design process. Their work was based on the monitoring of stochastic events (e.g. mortalities of wildlife) and the applied visual material (i.e.

pictures and icons) was mainly designed to assist semi- and illiterate members of the community to understand and recall the tasks. Another recent study is the work of Dougill and Reed (2005) for developing sustainability indicators for NRM at farm level in southwest Botswana. They proposed a framework for the participatory development of indicators through the combination of qualitative livelihoods analysis with more quantitative participatory environmental monitoring research so that the framework could integrate land-user knowledge with bio-geographical information. In turn, they proposed to disseminate findings through guidebooks, similar to the one proposed by Milton *et al.* (1998) but with the difference that these guides included the indicators generated by the participation of local communities and their use was intended to have as target user the local land-users. In this regard, there are some issues to consider about the use of visual representation in this area.

If visual aids (e.g. in guidebooks) are designed for being used by land-users, it is relevant to know how land-users may 'read' these images. For instance, Oba and Kaitira (2006) exploring the herder knowledge of landscape classification and environmental assessments in arid rangelands of northern Tanzania showed that the Maasai herders make use of plant species composition, richness, biomass and cover. Indeed, the presence/absence of key forage species and the increase of species less preferred by the herd constitute indicators of degradation commonly used among herders. If so, the design of visual aids should take notice of such findings and what the land-user really sees in the representation (e.g. a photograph) during the visual assessment.

Moreover, the validity of visual representations is still debated (Daniel and Meitner, 2001; Hull and Stewart, 1992). Validity is related to the congruency between the measurement tool and the measured property, that is, whether the tool (e.g. a photograph) measures the attribute or behaviour for what it was intended (e.g. farmer's assessment *in situ* of the rangeland represented in the photograph) (Alarcón, 1991). In this regard, if the monitoring process includes the comparison of visual assessment of representations and visual assessment of real environments by local communities, the validity of such representations constitute an important issue to be considered for the effectiveness of such processes. Likewise, the selection of the representation to be included in visual aids constitutes also a key step for the success of their use. For example, regardless of the framework used for the identification of the specific area that is relevant to a problem, i.e. a top-down ('expert-led') approach or a bottom-up ('participatory'/'conversational') paradigm, (Bell and Morse, 2001; Fraser *et al.*, 2006; Reed *et al.*, 2006), if the identified area is represented by photographic material, this representation only includes a limited part of the view of such area. Human vision manages an angle of 120° approximately whereas photographs taken with standard cameras of 35mm wide-angle lens handle an angle of only 60° (Palmer and Hoffman, 2001). Consequently, the selection of the approach to be used for visually sampling the area constitutes an important step in the development of such tools.

2.4.4. Different scenarios

Different approaches have been promoted for supporting the setting of goals and management strategies among stakeholders. These include, the use of scenario analysis, which allows managers to explore alternative future scenarios, or the use of decision support systems, which provide advice on how to develop management plans (Reed *et al.*, 2006). In this regard, a wide set of visual formats have been used, from drawings and photosimulations to more sophisticated evolving technologies such as digital three-dimensional (3D) representations (Ervin, 2001; Paar, 2006; Punia and Pandey, 2006). Indeed, different types of visual imagery (e.g. static, animated and virtual environment image formats) are promoted as not only powerful and efficient tools for communication of complex subtle and ambiguous relationships within data sets (Orland *et al.*, 2001) but also as visual aids in participatory research for "knowledge production" (i.e. formulation of research questions, sources of information and means for analyzing such information, interpretation and dissemination of findings and results) (Ellwood, 2006).

As a result, several approaches and participatory methods that rely to some extent on visual aids (e.g. drawings, photosimulations, and 3D models) and public participatory GIS (PPGIS) have been developed for improving communication among actors. Table 2.1 summarizes some frequently used participatory methods (Al-Kodmany, 2000). The application of the different methods can be viewed according to the empowerment it provides to the local people and the level of participation that is promoted. For example, McCall and Minang (2005) characterize the community participation according to its intensity and identify four levels. From lowest to highest: the first level is 'facilitation', so that manipulative and passive participation is promoted to introduce projects proposed by outsiders (e.g. participatory mapping in some rural appraisal studies), the second one involves approaches were outsiders consult selected issues with local people and interpret their answer into a 'scientific' framework (e.g. maps of needs), the third one includes the participation in decision-making of all actors across the different stages of the project (e.g. participation seen as a right) and the fourth one, seen as the strongest indicator of empowerment, promotes the independent initiatives from local people and self-mobilization.

On the other hand, the different methods suggested can also be judged by their effectiveness according to some features such as participants' characteristics, skills and experience, size of the area under analyses, available resources and stage of the process (Al-Kodmany, 2000). For instance, sketching and GIS are pointed out as suitable for problem recognition while photo-manipulation is regarded as suitable for identifying solutions to the problem (Al-Kodmany, 1999).

More recent studies also suggest that farmers particularly prefer the use of scales that reflects their day-to-day reality most closely (Bussink, 2003). If so, the use of the new technologies, which can represent different scenarios at farm level, might bring some unique research opportunities (e.g. view of scenarios linked to 'what if' questions). Indeed, the integration of visualization within software systems for support management decisions is more frequently promoted due to the advances in computer science. In this regard, an extensive review about the developing technology for computer modelling of each component of natural environments can be found in the work of Ervin and Hasbrouck (2001).

Table 2.1. Some visualization methods applied in participatory research

Method	**Description**	**Reference**
Activity location method	Participants' judgements about local planning are elicited by asking participants to place cards, which include representations of activities, on a base map.	Sanoff, 1991
Knowledge of emerging environmental preservation strategies - KEEPS	Using a sequence of sketches, different scenarios (past, present and possible future) are showed to the participants in order to elicit their perceptions about lost qualities and their opinions about which qualities they would like to keep.	Sanoff, 1991
Use of the on-the-spot sketching	Participants' opinions are captured within participatory workshops with the help of a design artist who draws sketches based on participants' guidance.	King *et al.*, 1989
Visual preference survey - VPS	Participants' preferences are elicited by asking them to rate different images based on a numerical scale.	Nelessen, 1994
Hands-on model building	3-D models are manipulated by participants in order to express their alternative site plans.	Nelessen, 1994
Citizen mural activity	Participants are asked to place words, symbols, sketches, photos and cartoons on wide sheets of butcher-block paper in order to show their opinions.	McClure *et al.*, 1997
Color-the-Map method	Participants create their own maps based on their land-use plans.	McClure *et al.*, 1997
Photo-portfolio method	Participants create a common vision through the selection of preferred images from a set and the subsequent organization of the selected images as graphical pasteboard displays.	McClure *et al.*, 1997
Use of GIS under a top-down model	A university or private firms give GIS support, data and analysis. Participants place questions and issues to providing firm.	Harris and Weiner, 1996
Use of GIS under the community-integrated GIS' model	Participants help to collect data and learn to use and analyze GIS provided by a third party.	Harris and Weiner, 1996

However, such technology has still its limitations. For example, the levels of realism or accuracy achieved by such representations are sometimes limited (Ervin, 2001). The development of 'good simulations' often requires the inclusion of details, parts and overall contents (Sheppard, 1989) but there is often a difference between the type of available data and the type of data necessary for a complete visual representation of a scene at farm level (e.g. a landscape). Indeed, some representations are built by the artistic manipulation of two-dimensional scanned photographic images but the proposed modifications are generally based on the 'designer's conception of how the project might look' and not on accurate data sources (i.e. 'data-driven') (Bergen *et al.*, 1998). On the other hand, the development of 'data-driven' representations includes a degree of abstraction due to problems such as the limited knowledge of physical laws and systems and the complexity of representing the interrelationship of their different elements, the magnitude of the data, level of detail problems, among others (Ervin, 2001). In this regard, Sheppard (2001) argues that although there is some information for current conditions of the landscape, actually there is few data systematically available to represent adequately visual attributes of the actual view or to infer the future conditions of a complete landscape in highly realistic visualization systems. Also, Daniel (1992) argues that despite a wide base study of the processes of measurement and statistics, which translate states of the world into data, the inverse processes, which could be used to translate the data into images, are mainly unexplored. He states, "There is rarely any formal evaluation of how well data-based inferences match the intended environmental conditions. Certainly there is no assurance that two individuals will translate a given set of data into the same environmental image, especially when those individuals differ in the amount and type of training for making such translations" (page 261, Daniel, 1992). In this regard, some research has being carried out to enhance the link of data-driven simulations and realism (Bergen *et al.*, 1998; Orland, 1994). Digital elevation models, information about roads, streams and boundaries, distribution of species and size classes and the appearance of individual species and growth forms within a species are being used, among others, as base information for creating some 3D visual representations of the landscape jointly with interactive design activities to increase realism. However, further research and suitable data are necessary for representations intended to be used by land-users at farm-level. In turn, a 'sufficient' degree of realism should be pursued so that visual representations can be valid surrogates in the perception of natural resources (Bergen *et al.*, 1998). The inclusion of higher degrees of abstraction might result in misinterpretation and decreasing of the communication (e.g. leaving gaps which viewers fill with their imagination) (Tress and Tress, 2003).

Moreover, in spite of the fact that there are some recent studies in the application of 3D visualizations, which showed positive results in the acceptability and effectiveness of such decision support media by communities (Lewis and Sheppard, 2006; Meitner *et al.*, 2005; Sheppard, 2005; Sheppard and Meitner 2005), such technology is still inaccessible to farmers and extension workers, especially in developing countries.

2.4.5. Land-user's perception

Despite there is a physical reality of the environment which exists independently of our perception about it, the study of NRM is also linked to complex human-environment interactions where the human perception of this physical reality plays an important role (Palmer and Hoffman, 2001). As a result, some researchers consider the use of hybrid sources (qualitative and quantitative information) to record not only physical aspects of natural resources but also to investigate opinions and concerns of local communities about biophysical processes (e.g. Batterbury *et al.*, 1997; Holland and Campbell, 2005; Nygren, 1999; Thomas and Twyman, 2004).

In this regard, the use of visual representations has been promoted as tools for eliciting stakeholders' perception, based on the fact that almost all people use visual stimulus in their daily lives and visual perception constitutes one of the main sources of information to enable us to interact with the environment. Whilst the decision making process of stakeholders might be guided by additional 'expectations and pre-existing mental content' which could influence the mental activity of the viewer (Turk, 1992), the use of visual representations gives new insights in the research of communities' perception. Indeed, over the last half-century visual tools have been used in a wide variety of research activities related to the perception of the environment. These include the research of landscape quality and aesthetic appraisal, perception of landscape changes by different groups (e.g. recreationists and ecologists) and environmental improvements, test of theoretical components, design review and regulations, research of human-environment interactions, agricultural and rural landscape dynamics (Paquette and Domon, 2001), among others.

Among the advantages of the use of visual representations for perception research, there is the argument that visual representations can be applied as a tool for the experimental control of the simulated environment (Daniel and Meitner, 2001). For example, some techniques such as edited images and computer simulations have been used not only to evaluate proposed changes to land use (Swaffield and Fairweather, 1996) but also to construct scenarios in the past where the photographic resource is limited (Gómez-Limón and Fernández, 1999). Moreover, another advantage of using visual representations could be based on the idea that we may process the images in a similar perceptual way to the direct experience. Trumbo (1999) stated that visual representation to express scientific principles, experimental data, or discoveries helps to convey meaning or to clarify ideas. In addition, he argued that whilst written language follows a cognitive processing, we react to the images before we understand them cognitively. In NRM, this argument can imply disagreements in the research findings according to the tool applied for eliciting stakeholders' perception. For example, Tyrväinen and Tahvanainen, (1999) found differences in the public responses about perceptions of forest management using two different evaluation methods, visual presentation and verbal questions. In their research, they linked the participants' responses given to verbal stimulus with the preconceptions that participants had and the responses given to visual stimulus with the real perceptions of the suggested scenarios.

Likewise, as it was argued in a previous section, further research is needed in the validity of visual representations. Several studies have reported the validity of the use of visual material in comparisons with the conduct of the viewer in the correspondent real environments (e.g. the use of photographs: Daniel and Boster, 1976; Shafer and Richards, 1974; the use of photosimulations, videos as well as simulation of physical environments using computer graphics: Bishop and Rohrmann, 2003). Nevertheless, its validity and reliability (i.e. consistency of the assessments among evaluators) in a context of NRM where farmers or extension workers and their daily tasks are involved is an open research field. For instance, Dougill and Reed (2005) in their study of sustainability indicators for NRM at farm level in southwest Botswana reported that the knowledge of the indicators among Kalahari pastoralists was sparsely dispersed and differed between different social groups (i.e. classed by land ownership status). Some relevant concerns elicited by this finding might include questions such as: Are visual representations valid tools for perceptual assessment if these do not include the local knowledge and the visual clues that the viewers (e.g. the Kalahari pastoralists) use to manage? Even if leaders of the target community could be easily identified and involved in the development process of the visual material, this does not ensure the validity of such tools, due to the possible presence of different profiles of information management among community members. For example, when there is a differential access to information and ownership of resources according the gender, rural women often manage different important knowledge about foods, medical herbs, fibres and fuels (McCall and Minang, 2005). However, this knowledge is often 'invisible' in information given by men's account.

Moreover, Palmer and Hoffman (2001) reviewing some studies which reported positive results about the validity and reliability of visual representations, found problems in the research methodology applied, which could change the reported findings of such studies. They stated, "...authors almost always report the reliability of the group's mean rating and not the reliability of individual ratings. Similarly, when evaluating the validity of photographic landscape representations, authors almost always report the correlation of mean ratings for a group of representations compared to ratings of the actual settings they represent" (page 151, Palmer and Hoffman, 2001). In this sense, they argued that an error in the selection of the unit of analysis might lead to observed errors in the results of the analysis. That is, the analysis done in grouped data may provide different results with non-grouped data (Robinson, 1950). Moreover, the visual sampling procedure again is determinant in the studies of validity of visual representations, which will be tools for research in human perception about natural resources. The method applied in the selection of visual representations determines the representativeness of the visual material (Hull IV and Revell, 1989).

2.4.6. Some additional concerns related to the use of visual representation in NRM

2.4.6.1. Suitability of the use of visual representations

Not all types of information are suited to be represented by visual material. In order to represent different scenarios (i.e. 'before' and 'after' photosimulations), it is evident that the representation must include a physical and visible change (Sullivan *et al.*, 1997). For instance, the water quality or the change of temperature would be characteristics difficult to observe in an image. In this regard, Hetherington *et al.* (1993) reported that still photographs were less sensitive to assess changes in the flow levels of a river than other types of representations, which included motion display. Nevertheless, whenever the use of a relevant visual representation is feasible, the validity and the characteristics of the use of the representation should be considered.

2.4.6.2. Ethical concerns

Owing to the persuasive power that the use of visualizations can have on perceptions and decisions and the reliability of such representations, ethical concerns have been expressed by some researchers about the unstructured use of visual representations for decision support (Palmer, 1994; Sheppard, 2001; Sullivan *et al.*, 1997). Despite the scarce scientific research on the effective influence of visual representations on the decision making process, the inaccuracy or bias of such tools is a matter of interest due to its potential impact. In this regard, Sheppard (2001) discusses the risks of using the capability of visual tools as 'crystal balls', which would permit the handlers of the visual representations to convince users with inexact or incomplete material. Concurrently, Obermeyer (1998) points out that one of the risks of using visual representations is that no matter the underlying ideas or data, the visualization technology can make a proposal appear more authentic and authoritative than it otherwise might be. Indeed, flashiness of visual representations can produce false legitimization of 'bad' data (Abbott *et al.*, 1998; McCall and Minang, 2005).

As a result, Sheppard (2001) proposed the establishment of a framework, which could guide the creation and use of visual representations. He stated that this framework should include general principles and responsibilities laid down in a code of ethics, best practice guidelines, standards, and specific procedures to assist practitioners directly in their visualization work and professional support networks and institutions.

However, little effort has been reported in this sense. Further work is needed in this field since this ethical concern is relevant for ensuring the efficiency of visual tools, the trust of the stakeholder and the adoption of such tools. For instance, Obermeyer (1998) argued that local stakeholders are mostly familiarized with the resource represented so any inconsistency or biased manipulation found in the representation could decrease the confidence of the user or make invalid the project.

2.4.6.3. Costs

Another major drawback in the use of new technologies applied to the building of visual representations for NRM is related to the implementation costs. In this regard, the common use of photographs as surrogates of real environments for research on environmental perception is due to the fact that the cost of the research on the real environment (e.g. transport of participants to the sites of interest, or implementation of a scenario in a real environment) is prohibitively expensive (Daniel and Meitner, 2001). Although the photographic manipulation is not generally automated and so it is time-consuming, the costs are still far more accessible compared to other options.

Other than photographs, alternative technological innovations for visual representations such as computer-generated environments are not frequently used due to the limited accessibility to the technology and the high costs of the required equipment (i.e. computers, software, and training between others). In general, these more sophisticated tools for visual representation are produced by universities, software and consultant companies, and agencies for environmental management (Tyrväinen and Tahvanainen, 1999). Nevertheless, the infrastructure necessary for their use (i.e. computers where to display the representation) is not always accessible for all the target groups in NRM (i.e. farmers or extension workers in remote areas), especially in developing countries. In contrast with developed countries where an increasing in the use of computer by farmers have been reported (Batte, 2005), high levels of poverty, infrastructure limitation and limited formal education still constitute major challenges for technology access in rural areas of developing countries (Pade *et al.*, 2006).

2.5. Conclusions

This paper has reviewed some current applications that visual representation has in NRM. Their applications in this field are reported as promising across the literature. However, despite many claims of validity of the use of visual material in NRM, the verification of such claims needs further research work, especially in the context of NRM and the use of visual representations by communities and land-users.

NRM depends mainly on decision-making carried out by land users at farm and parcel level (Bussink, 2003). In this regard, stakeholder participation is essential for fulfilling the requirements of Agenda 21 and increasing the cooperation of local inhabitants (Ball, 2002) but there are some communication gaps that could be bridged by promoting the use of visual representations. As it is shown in this review, the use of visual representation in NRM is not restricted to its role in the merely visual descriptive approach as an informative tool. It is also promoted in participatory research for the knowledge transfer in a bidirectional way (e.g. from scientists to managers and from managers to scientists and within groups). Nevertheless, there are some problems to be solved and several concerns to be overcome. Are there in effect visual representations tools that narrow the communication gap between researchers and farmers? (Bussink, 2003). Related to this, many open research questions still persist. Some basic questions identified are:

- Are there valid visual representation tools for NRM at farm level? That is, are the farmer's responses to a visual representation of a given zone (e.g. a photograph of a landscape) equivalent to the farmer's response to the view of the same zone *in situ*? (Ervin, 2001)
- If so, what characteristics of the representation are important? (e.g. realism) (Ervin, 2001)
- Could visual representations be considered a reliable tool in NRM or are there differences in reliability according to different natural resource managers?
- Which approach should be followed for the selection or development of visual representations? E.g. which method of visual sampling is better when photographic material is used to represent a zone and is collected for perceptual research?
- Which is the success of visual representation in participatory research in areas where the financial and skill-based resources are limited? E.g. in lower-income countries (Williams and Dunn, 2003).
- How is the visual literacy of local managers? What visual elements of the representation are important for visual assessment among local communities? Are there differences among farmers according to these visual elements relevant for the visual assessment of the representation? If so, what visual elements are important for each group? Do these differences appear when other formats of information are presented (e.g. verbal/written information)?
- What degree of accuracy/precision is needed in visual representations for participatory research and what would be the costs of applying a lower degree of accuracy/precision? (McCall and Minang, 2005).

Consequently, further research is needed on these questions to get a better understanding of the suitability of the use of visual representations by land-users, before the attribute of "common coin" can be given to such tools in NRM.

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Chapter 3

Exploring the validity of visual representation for grassland assessment[1]

3.1. Abstract

The validity of the use of visual representation in natural resource management has been commonly examined from the aesthetic and scenic beauty perspective. However, other concepts are relevant for the decision-making process of natural resource managers in developing countries, especially in grassland areas where the population's livelihood is based in part in the grazing management activity. On the other hand, visual representation is pointed out as a tool to enhance decision support systems for natural resource management. The purpose of this work is to explore the validity of visual representation in performing assessments about common concepts used in grassland management by extension advisers, whose role in the chain of technology transfer is critical in developing countries. This exploratory study took place in a grassland area of the Peruvian High Plateau. The group of participants included recognized extension workers working in the study area, whose daily activities were mainly related to grassland management. Results show visual representation as a valid and reliable tool for performing assessments on grassland condition and stocking rate whenever key characteristics of the visual representation are taken into account during the development of such material. The discussion remarks on the participants' responses to visual material use for assessing grassland, the importance of the representativeness of the selected visual material, the limitations of the study and the need for more research in this topic.

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[1] Cruz, M., Quiroz, R. and Herrero, M. 2005. Exploring the validity of visual representation for grassland assessment. Environmental Management (submitted).

3.2. Introduction

Rangelands constitute complex systems where human-nature interactions are of importance due to their influence in the resilience of these ecosystems and their effect in the change of flora and fauna composition (Le Houerou, 1997; Walker and Janssen, 2002). The potential primary production of rangelands is related to the impact of outside influences such as grazing pressure, fire and climatic factors (Behnke *et al.*, 1993; Sivakumar, 1992). In this regard, environmental degradation of arid and semi-arid rangelands cannot be only explained by vegetation changes alone but as moving between multiple states driven by non-equilibrium and abiotic influences (Behnke *et al.*, 1993). For example, prolonged drought periods or heavy grazing or a combination of both, produce a decline of water infiltration or a lost of perennial grass cover (Walker and Janssen, 2002). On the other hand, the welfare of people living on rangelands usually depends mainly on activities related to the livestock production and grazing management and hence the grazing capacity is an important part of their livelihood. As a result, the assessment of the rangeland condition constitutes the cornerstone of any rangeland management system (Friedel, 1991; Jordaan *et al.*, 1997; Tainton, 1988).

In spite of the existence of different range condition assessment techniques (Benkobi *et al.*, 2000; Jordaan *et al.*, 1997; Pamo *et al.*, 1991) and the debate between scientists about which factors to include in its estimation (Friedel, 1991), the most frequently used methods by both extension workers and farmers are based on subjective evaluation linked to visual assessment (Jordaan *et al.*, 1997). Their relative simplicity and facility of its use are the major reasons for its application. However, the results of the assessment done by different evaluators can vary according to the evaluator's characteristics (e.g. experience).

Because of this, there are some efforts for developing visual support material, which can help the evaluator in his task of characterizing the vegetation of a study area. In this regard, photographs of ecosystems previously assessed by other methods (i.e. ground inventories) can serve as comparative support material for the assessment of other similar areas. In this way, the evaluator makes a faster and easier characterization of vegetation condition of his study area by means of comparing the visual similarities of the study area with the ones shown in the photographs (Ottmar *et al.*, 1998; Ottmar *et al.*, 2004; Wright *et al.*, 2002.). For example, Milton *et al.* (1998) designed a rangeland evaluation guide with photographs, maps and diagrams for land users with a minimal knowledge of plants and soil processes. Using subjective five-point scores, the guide was intended to avert rangeland damage by providing assessments of rangeland health. In turn, Dougill and Reed (2005) produced rangeland evaluation guidebooks in order to support the dissemination of sustainability indicator information in southwest Botswana. Making use of the collaboration of local land-users for the indicator development, their objective was not only to use accurate and reliable indicators but also to identify rapid, cost-effective and easy to use indicators in rangeland context. In this regard, the use of pictures and icons can also help in a participatory approach to assist semi- and illiterate members of the community in the understanding of tasks in data collection (Stuart-Hill *et al.*, 2005).

Apart from this use, visual representation of natural resources is a growing research area (Ervin, 2001) due to its application in the development of decision support systems for natural resource management. In spite of the advances of computer graphics and software applications created for the production of visualization showing different natural scenarios, real or hypothetical, (e.g. 3D Nature, Vantage Point, Smart Forest, SimForest, among others), the use of visualization in natural resource management has still as its main users the researchers themselves and not the natural resource managers (Stoltman *et al.*, 2004). Moreover, the validity and applicability of visual representation for decision-making in developing countries remains as a research topic in need of further investigation. Most of the research studies designed to study the validity of its use, were restricted to the study of scenic preference (studying concepts such as beauty and aesthetics value of the landscape) and were not necessarily related to other concepts used in decision-making process of natural resource management in developing countries (e.g. grassland condition assessment). Furthermore, some of these studies were based on non-representative participant sample of the natural resource managers (what Blascovich *et al.* in 2002 refers to as 'samples of convenience', e.g. students). These participants may not have the experience and motivation of the manager who has to deal with daily decision on the field and so, the same perception and reaction to the same stimulus (i.e. visual representation).

Apart from this, it is argued that in technology transfer, the extension workers play a critical role in planning and the decision making chain (Budak *et al.*, 2005; Scherr, 1992; Solano *et al.*, 2003). The important function of extension workers as 'catalysts and information brokers' (Scherr, 1992) is recognized not only by the researchers but also by the farmers who regard them as one of their most important common personal information sources for 'problem detection' and for 'seeking new practices' (Solano *et al.*, 2003). In this sense, the study of the use of visual tools and its validity by the group of extension advisers is important if such tools are proposed for supporting decisions in natural resource management.

In this regard, this paper presents exploratory research the purpose of which is to study the validity of the use of visual representation by extension workers in a grassland area of Peru and its applicability by such a group. For this, the reliability of assessments, validity of its use compared with real environments and the level of realism-abstraction of the visual representations are examined in a workshop organized with extension advisers working in the area.

3.3. The study area

The study area is located in Azangaro, Puno, (longitude: -70.36, latitude: -14.83, altitude: 3850m) which exhibits a grassland ecosystem type of the High Plateau area of Peru. Predominant natural pasture extension characterizes the area so that the management of an intensive grazing activity is characteristic in the area under study. Due to the grazing and biophysical conditions, the study area presents a wide variability of pasture conditions (figure 3.1). Climate imposes stresses on local land-users through sharp climatic fluctuations such as severe droughts which are typical of the El Niño southern oscillation in the Andean High Plateau (Preston *et al.*, 2003; Woodman, 1998). In spite of this, limited published information was found about the different grassland conditions of the specific study area as well as the criteria used by local land users for classifying their grasslands. León-Velarde and Izquierdo (1993), working in the High Plateau area, reported the existence of different grassland conditions in close areas according to the palatability of the predominant species for sheep (table 3.1). In turn, according to the last agricultural census in the study area (INEI, 1994), the main types of livestock in the province of Azangaro are sheep, South American camelidae and cattle, among others (table 3.2).

Table 3.1 Condition of the different types of High Andean grasslands

Condition	Type of grassland
Excellent	Scrub of *Festuca dolichophylla*; High Andean Bofedal
Good	*Muhlenbergia* sp. and *Distichlis* sp.; *Festuca orthophylla*; Bofedal of *Calamagrostis* sp.; Scrub of *Festuca dolichophylla*; Grassland without grazing activity
Regular	Meadow of *Bromus unioloides*; *Parastrephia* sp. and *Muhlenbergia* sp.
Poor	Scrub of *Stipa* sp.; Tholar of *Parastrephia* sp.; *Frankenia* sp., *Parastrephia* sp., Scrub of *Stipa ichu*, *Tetraglochin* sp., Scrub of *Festuca orthophylla*; *Festuca orthophylla*/*Parastrephia* sp.; *Aciachne* sp.

Source: León-Velarde and Izquierdo, 1993

Table 3.2 Type of livestock in Azangaro, Puno, according to the number of animals in 1994

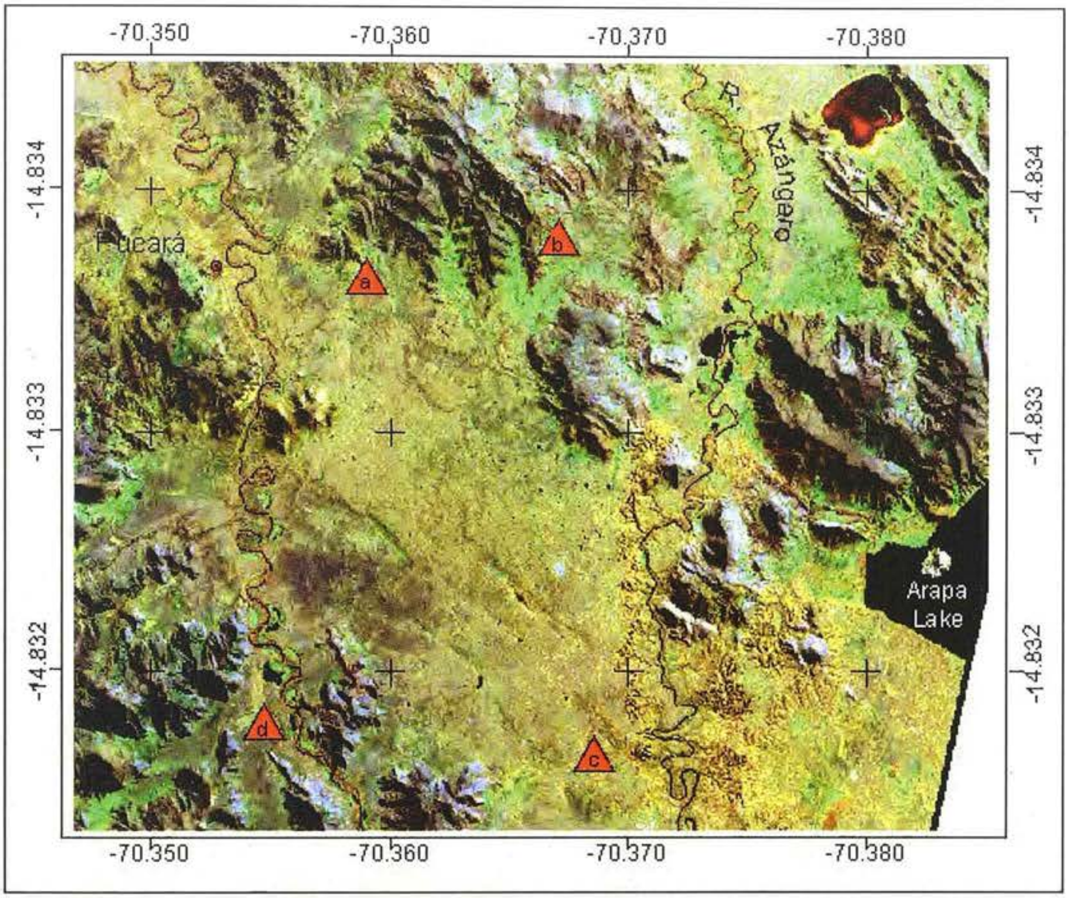
Livestock	Number of animals*
Sheep	579500
South American camelidae (alpaca, llama and guanaco)	135100
Cattle	98000
Equine	16700
Porcine	15300

Source: III National Agricultural Census (INEI, 1994)

* Number of animals was rounded to the nearest hundred.

As a result, agricultural production systems in the study area are oriented toward grazing, predominantly sheep and alpacas. According to the study of IIP Qollasuyo (2005), the study area was located in one of the zones with biggest stocking rates in the Peruvian High Plateau (for sheep: 0.43 AU/ha/year; for alpaca: 0.64 AU/ha/year and for cows: 0.13 AU/ha/year). Some other researchers have also reported the existence of a rotational grazing in some zones close to the study area, whereby shepherds move their livestock to new grasslands according to the season of the year (Swinton and Quiroz, 2003). In this regard, Swinton and Quiroz (2003) indicate that the use of rotational grazing contributes to reduce the number of range species lost and the probability of poor pastures in the area.

Figure 3.1. Satellite image of the study area and selected zones.



Source: TRFIC – Tropical Rain Forest Information Center. Michigan State University. Path: 003 Row: 070. Triangles represent the selected zones across the study area: (a) Zone 1, (b) Zone 2, (c) Zone 3, (d) Zone 4

3.4. Participants

It has been argued that the integration of research and extension in agricultural research is not always strong due to different reasons such as geographic isolation of extension workers and institutional and administrative factors (Honadle, 1994). In this sense, the target group of the present study was the extension advisers working in the study area due to the importance of their role in the technology transfer as well as their daily activities related to grassland condition assessment. A group of seven professionals who were identified as the main advisers working in the study area participated in the research. The subjects were representative of the extension advisers who used to work in pasture programs in the area at the time of the study (e.g. the ones carries by the local university Universidad Nacional del Altiplano, the national agricultural research institute INIA, and the Alpaca Cooperative CECOALP). All of them were agronomy engineers. All of them reported to work in daily activities with grassland management and condition assessments at the time of the present study. 3 participants reported to have more than 10 years of experience in grassland evaluation (one of them was the professor of the grassland course of the local university, while the other 2 were principal researchers of projects about grasslands in the study area), 2 participants reported to have between 3 and 7 years of experience in such task and the remaining 2 participants reported to have less than 3 years in grassland assessment. One participant did not have any computer experience, while the rest of participants pointed out to work occasionally (3 participants) and frequently (3 participants) with computers. The latter information was relevant for the exploration of a future use of other types of visual representation (i.e. computer based representations) and some characteristics (e.g. level of realism) for the validity of a possible future use of such technologies by this human group.

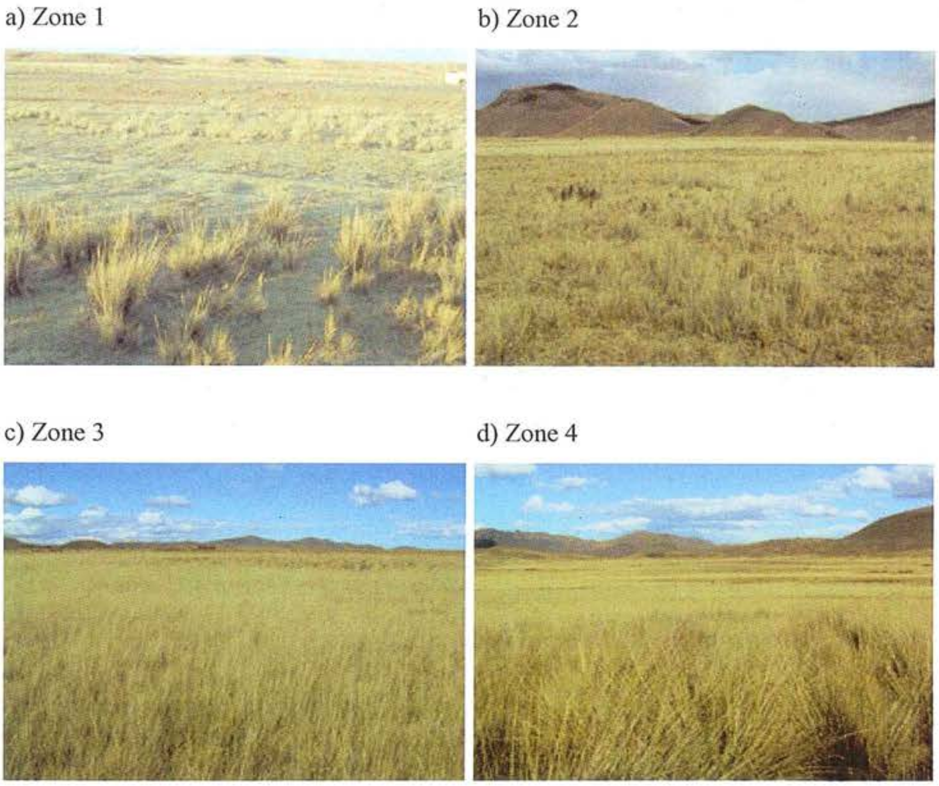
3.5. Material and Methods

Four zones were selected across the study area (figure 3.1) in order to represent different grassland conditions in the study area. A complete evaluation of the different grassland conditions and the types of grassland species in the study area was not possible to carried in this work. However, the selection of the zones was supported by the team of the National Agricultural Research Institute (INIA), which was working in the area and had wide knowledge of the grasslands in the study area. The selection was restricted to chilliguares and took into account the accessibility of the zones from the road. Apart from this, the selection and the definition of condition were left to the criterion of the local researcher. Further research is needed to get knowledge about the criteria that local land users apply for the classification of their grassland. As far as a literature review allowed to discern, little knowledge is available in the literature about the local knowledge used by land users in this area for defining the condition of grassland.

For each zone, a photographic survey of the field was performed to produce a complete photographic dataset depicting vistas of the four pasture conditions studied (figure 3.2). The photographic survey was carried out taking photographs along walks through each zone. The scenes to be photographed were selected with the objective of representing the full range of physical characteristics for each zone (e.g. vegetation type, topography) (Hull IV and Revell, 1989; Schroeder and Daniel, 1981). In turn, the photographs were taken horizontally at the eye level of the observer using a tripod.

In order to study applicability of the use of visual material for the assessment of rangeland condition, first, a trip was carried out with the participants for registering their judgements *in situ* of the area under study. The four zones selected for the photographic survey were visited and the participants were asked to rate each zone using a numeric scale from 1 to 10 according to the grassland condition. A 10-scale was selected following previous studies where the assessment of landscape photographs was involved (e.g. Tahvanainen *et al.*, 1996). The only information provided for this task to the participant was that 1 should be linked to poor condition and 10 to excellent condition. The exact definition of 'poor' or 'excellent' and the definition of condition were left to the criterion of the participant. In addition, the participants were also asked to record their estimation about the stocking rate (the number of animals for which the study zone could provide adequate dry matter forage for a specified length of time) expressed in animal units/ha/year and any key element for their judgement. In the present study, it was assumed that the estimation of stocking rate would provide information about the validity of visual representations for the determination of a practical concept in grazing management in contrast with more abstract concepts evaluated in other validity studies (i.e. scenic beauty). For this, the estimation of stocking rates was based only on the visual assessments of the zone by the participants. Stocking rate depends on the amount of herbage biomass available in the area and in conjunction with other factors (e.g. grazing duration) could not only determine the degradation of the zone due to not only changes in vegetation but also soil structural alterations induced by grazing animals (Bilotta *et al.*, 2007).

Figure 3.2. A sample of the photographs collected for each zone.



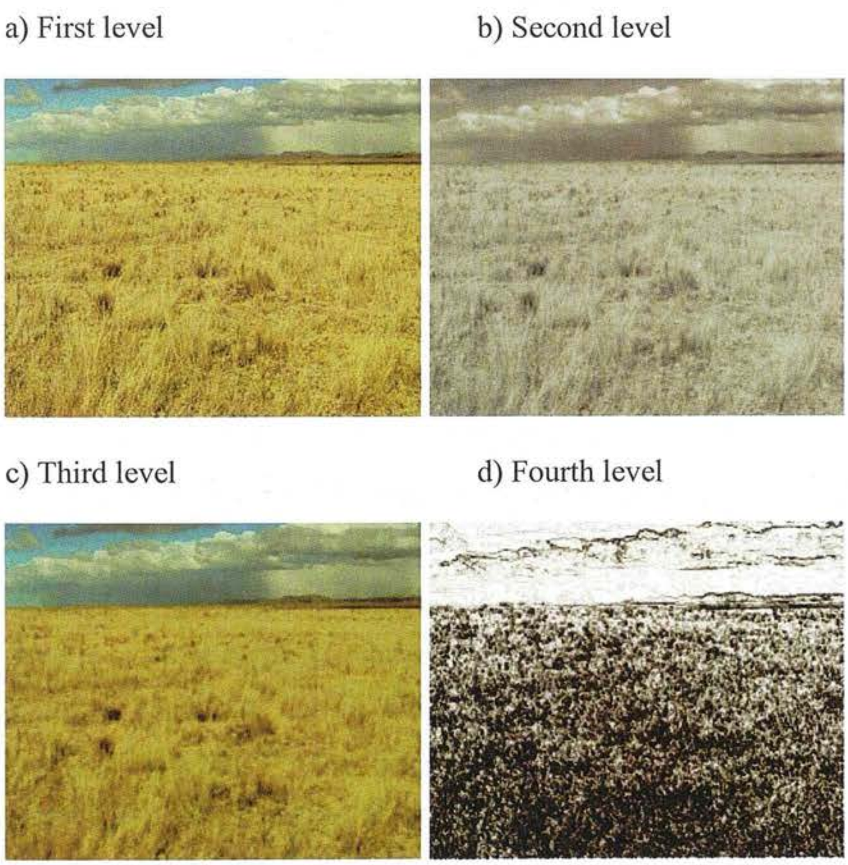
After the trip, different tasks were performed with the participation of the extension workers to get further knowledge of the use of visual material according to the purpose of the study. The first task was oriented to study if similar judgements of pasture conditions could be obtained through the evaluation *in situ* and photo-based material. For this, a comparison between the previously collected in-situ judgements made by the participants and photo-based judgements was conducted.

Forty photographs (10 photographs per zone) from the dataset were selected. The selected number of photographs was chosen taking into account the available time for interviewing as well as trying to prevent a photographic survey which could be cognitively overwhelming. Respondents were asked to rate each photograph according to the grassland condition using the numeric scale from 1 to 10 (the same scale applied to the *in situ* judgements). The participant was asked to rate the scene based on the visible characteristics shown on the photographs and no instruction was given for trying to identify or remember any particular area. The 40 photographs were shown randomly to the participants to eliminate order effects. The randomization for this was done not only within zones but also across zones. The respondents were also asked to register for each photograph an estimate of the stocking rate that they consider to correspond with the represented area and any element that they could identify or consider relevant for the assessment. The participants perform the task independently (each participant alone and not as a group).

Finally, an additional task was carried out in order to explore some characteristics of other types of visual representations (i.e. realism of the representation). This was with the objective to get knowledge about the validity of a possible future use in the study area of other types of representations that involves certain degrees of abstraction (e.g. computer-based representations). In order to study the participants' responses to different levels of realism-abstraction, 8 additional photographs were selected to represent the four selected levels of pasture conditions (2 photographs per zone). For each one of these photographs, four alternatives of realism-abstraction conditions were prepared based on the study of Daniel and Meitner (2001).

The first level of realism was obtained converting the initial photograph (Canon jpg 1600 x1200 resolution) to RGB colour space and a resolution of 1024 x 768 (screen resolution used for the presentation). The second level of realism/abstraction was obtained converting the previous image to a greyscale colour space. The third level of realism/abstraction was obtained from the original photograph by applying the 'facet' filter in Adobe PhotoShop and resized to 1024 x 76. Applying to the original photograph the 'sharpen more' convolution filter and 'find edges' filter in Adobe PhotoShop obtained the last level of realism/abstraction. The contrast was increased to a value of +30 and the image was resized to a resolution of 1024 x 768. All images were saved using the Targa image file format (16 bit/pixel). Figure 3.3 shows a sample of the visual material with the four levels of realism/abstraction used in this study. The images were shown randomly to the participants, who were asked to assess the grassland condition and estimate the stocking rate in a similar way as the first task was performed (based on the visual assessment of the zone).

Figure 3.3. A sample of the four alternatives of realism/abstraction, from the first to the fourth level of realism-abstraction (a-d).



3.6. Results and Discussion

3.6.1. Reliability of assessments

Firstly, the reliability of the assessments given by the study's participants was measured by the calculation of the Intraclass Correlation Coefficients (ICCs). ICC is commonly applied in the study of reliability or agreement of rater's judgements (Palmer and Hoffman, 2001) since it measures the proportion of the variance that is attributable to objects of measurement (McGraw and Wong, 1996). The calculation of ICCs uses the mean squares from an analysis of variance (Harris, 1913) so the selection of the variance model of the data determines the method for calculating the ICC. For the present study, a two-way random effect model was applied (McGraw and Wong, 1996). Table 3.3 gives further description of the model applied and shows the ICCs calculated for *in situ* and photo-based assessments of grassland condition and stocking rate given by the different advisers. Results show high ICCs for the four cases (0.942 for *in situ* assessments of grassland condition; 0.942 for *in situ* assessments of stocking rate; 0.867 for photo-based assessment of grassland condition and 0.852 photo-based assessments for stocking rate given by advisers). In this sense, photo-based assessments given by extension workers were highly reliable (confidence intervals of 0.800 to 0.996 for *in situ* assessments of grassland condition; 0.799 to 0.996 for *in situ* assessments of stocking rate; 0.805 to 918 for photo-based assessment of grassland condition and 0.784 to 0.908 photo-based assessments for stocking rate with 95% confidence), suggesting that the advisers follow the same pattern of assessment despite any apparent differences in the precise assessment. Working experience in the same study area as well as previous training about grassland assessment of working advisers may be related to these results. In spite that both types of assessments (*in situ* and photo based) show high reliability, the results reveal that assessments of extension workers were slightly more reliable in evaluations based *in situ* than on photographs.

The ICCs obtained were high in comparison with reliability coefficients expected from research among psychometricians (0.70-0.80) (Palmer and Hoffman, 2001). Moreover, the majority of ICC were above 0.90 which is pointed out as the expected value in applied settings as reference for important decisions (Nunnally, 1978; Palmer and Hoffman, 2001). These results suggest that the use of photograph was useful to measure difference in the adviser perception about the grassland condition and stocking rate in a consistent way.

Table 3.3. Intraclass Correlation Coefficients (ICCs) of assessments given by advisers.

Assessments	Intraclass Correlations (ICCs) (a)	n	k	95% Confidence Interval	
				Lower Bound	Upper Bound
Assessments In-Situ of grassland condition	0.942	4	7	0.800	0.996
Assessments In-Situ of Stocking Rate	0.942	4	7	0.799	0.996
Photo-based assessments of grassland condition	0.867	40	7	0.805	0.918
Photo-based assessments of stocking rate	0.852	40	7	0.784	0.908

(a) The variance model used in the present study was the two-way random effects model explained by McGraw and Wong (1996): $x_{ij} = \mu + r_i + c_j + e_{ij}$ where $i = 1,...,n$; $j = 1,...,k$; μ is the population mean for all observations; r_i are the row effects; c_j are the columns effects and e_{ij} are the residual effects. For the present work:

n = the number of assessments made by each evaluator. For *In-Situ* assessments, n is equal to the number of zones since there was 1 *In-Situ* assessment per zone. For photo-based assessments, n = 40 since there were 40 photographs evaluated by each participant. The latter was based on the fact that each photograph was assessed individually.

k = number of evaluators so k=7 in all cases.

3.6.2. *Validity of visual representation use*

The validity of the use of photographic material for grassland condition assessment was examined comparing the photo-based assessments with the *in situ* assessments by the calculation of Pearson's correlation coefficients. The use of these coefficients is frequently applied for the study of validity of photographic material since they give information about a similar response pattern between the assessments performed *in situ* and the ones based on photographs (Palmer and Hoffman, 2001). Table 3.4 shows the Pearson's correlation coefficients between both groups of answers. For this, two ways of analysis were used. The first used a mean rating for the ten photographs by a participant at each zone against the corresponding *in situ* rating given by the same participant (table 3.4a) and the second used the individual rating that the participant gave to each photograph against the *in situ* rating of the zone where that photograph was taken by the same participant (table 3.4b).

Despite the high values of correlation coefficients observed in both analyses (all of them above 0.8), there were observed higher coefficients in the case where the mean rating for the ten photographs at each zone was used (0.932 and 0.855 for the use of mean photo-based assessments of grassland condition and stocking rate respectively vs. the correlation coefficients obtained for the use of individual ratings of each photograph: 0.891 for grassland condition and 0.817 for stocking rate).

Table 3.4. Pearson's correlations coefficients between in-situ assessments and photo-based assessments.

(a) Correlation between the *In Situ* assessments (one per zone) and the mean of 10 photo based assessments per zone (one mean per participant per zone).

	In Situ Assessments of Grassland Condition	*In Situ* Assessments of Stocking Rate	Photo Based Assessment of Grassland Condition (Mean per zone)	Photo Based Assessment of Stocking Rate (Mean per zone)
In Situ Assessments of Grassland Condition	1	0.928(**)	0.932(**)	0.837(**)
In Situ Assessments of Stocking Rate	0.928(**)	1	0.922(**)	0.855(**)
Photo Based Assessment of Grassland Condition (Mean per zone)	0.932(**)	0.922(**)	1	0.896(**)
Photo Based Assessment of Stocking Rate (Mean per zone)	0.837(**)	0.855(**)	0.896(**)	1

n=28 (Number of observers = 7 x Number of Zones = 4); Degrees of freedom = 26

** Correlation is significant at the 0.01 level.

(b) Correlation between the *In Situ* assessments (one per zone) and the individual photo based assessments (10 photographs per participant per zone).

	In Situ Assessments of Grassland Condition	*In Situ* Assessments of Stocking Rate	Photo Based Assessment of Grassland Condition (Individual photograph)	Photo Based Assessment of Stocking Rate (Individual Photograph)
Photo Based Assessment of Grassland Condition (Individual Photograph)	0.891(**)	0.882(**)	1	0.867(**)
Photo Based Assessment of Stocking Rate (Individual Photograph)	0.800(**)	0.817(**)	0.867(**)	1

n=280 (Number of observers =7 x Number of Photos per Zone = 10 x Number of Zones = 4); Degrees of freedom = 278.

** Correlation is significant at the 0.01 level.

Table 3.5. Paired Samples Test for photo-based and in-situ assessments.

		Paired Differences					t	df	Sig. 2-tailed
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
(a)	*In Situ* - Photo Based Assessment of Grassland Condition (Mean per zone)	0.350	1.153	0.218	-0.097	0.797	1.605	27	0.120
	In Situ - Photo Based Assessment of Stocking Rate (Mean per zone)	0.217	0.695	0.131	-0.052	0.487	1.654	27	0.110
(b)	InSituCondition - Photo-Based Assessments of Grassland Condition (Individual Photograph)	0.350	1.338	0.080	0.193	0.507	4.376	279	0.000
	InSituStock - Photo-Based Assessments of Stocking Rate (Individual Photograph)	0.217	0.793	0.047	0.124	0.310	4.588	279	0.000

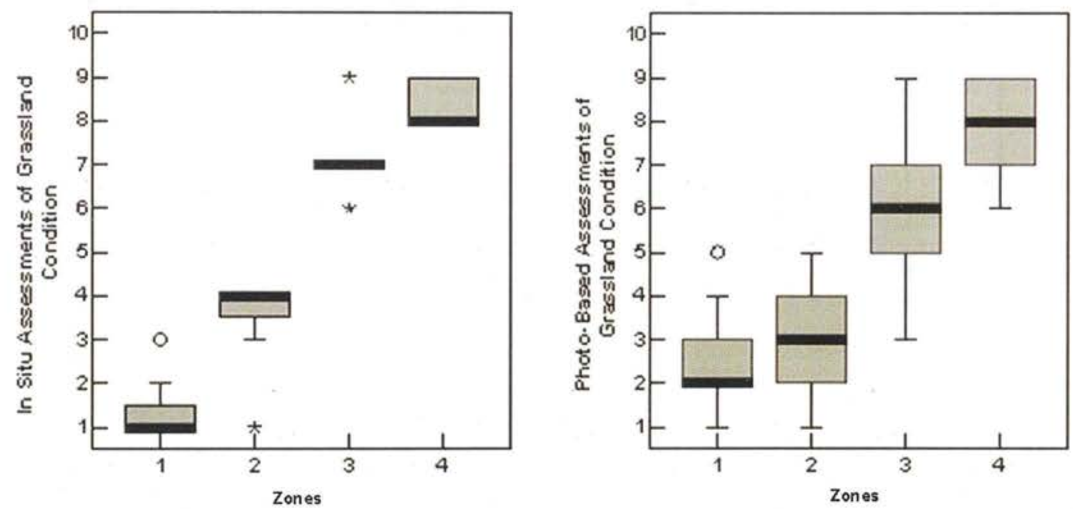
(a) Mean rating for the 10 photographs at each zone and *In Situ* assessment at each zone. n=28 (Number of observers = 7 x Number of Zones = 4)

(b) Individual rating for each photographs and the corresponding *In Situ* assessment at the zone where the photograph was taken. n=280 (Number of observers =7 x Number of Photos per Zone = 10 x Number of Zones = 4)

"A high correlation is possible even though the actual values [of the ratings obtained *in situ* and photo-based] may systematically differ by a significant amount" (page 154, Palmer and Hoffman, 2001). For this reason, a paired Student's t-test was used to study if there was a significant difference between *in situ* and photo-based assessments. As previously, both the mean rating for the ten photographs per zone and individual rating for each photograph was used. Results are shown in table 3.5. As it is shown in these results, the use of mean rating does not show a significant difference between *in situ* and photograph ratings. Nevertheless, when the individual rating for each photograph is compared with the *in situ* rating of the zone where the photograph was taken, a different result is obtained. In this case, a significant difference ($p<0.001$) is shown between both groups of assessments for both grassland condition and stocking rate. This difference between the results obtained by the analysis of individual ratings and the ones obtained by the analysis of the group's mean rating have previously been reported in studies about scenic beauty and aesthetics (Bergen *et al.*, 1995; Palmer and Hoffman, 2001). The problem of using a group measurement to substitute individual measurements was initially demonstrated by Robinson (1950). In his work, Robinson showed that the use of grouped data might give erroneous results due to a bad selection of the unit of analysis. In contrast, the use of the mean rating of the several photographs is still a common practice in preference studies (Palmer and Hoffman, 2001). In order to avoid this problem in the use of photographic material, the assessment of each independent scene should be the unit of analysis. However, it should be taken into account that each photograph is a partial representation of the complete zone and consequently, the selection of the photograph is critical for the content validity and hence for the validity of the use of visual representation.

Figures 3.4 and 3.5 show the distribution of grassland condition ratings and stocking rate estimates respectively. Both figures show (a) *in situ* assessments as well as (b) the individual ratings for each photograph per zone. It is observed that while the values observed *in situ* are more clearly separated between different zones, the values observed in the photo-based assessments for both grassland condition and stocking rate do not present the same case. In the latter, the median values of the assessment per zone are usually situated under the median value of the corresponding *in situ* assessments (exceptions are the stocking rate estimate for the first zone as well as the grassland condition for the fourth zone). This could suggest a sub-estimation on the photo-based estimates compared with the corresponding *in situ* assessments.

Figure 3.4. Boxplots showing the Distribution of Grassland Condition Assessments per zone given by the participants. (a) *In situ* and (b) photo-based assessments.



(a) *In Situ assessments for each zone.* (b) Photo-Based assessments for each zone.

The box length shows the interquartile range (IQR) for each zone (the lower part of the box shows the first quartile Q_1, the bold line dividing the box shows the median of the data for each zone and the upper part of the box shows the third quartile Q_3).

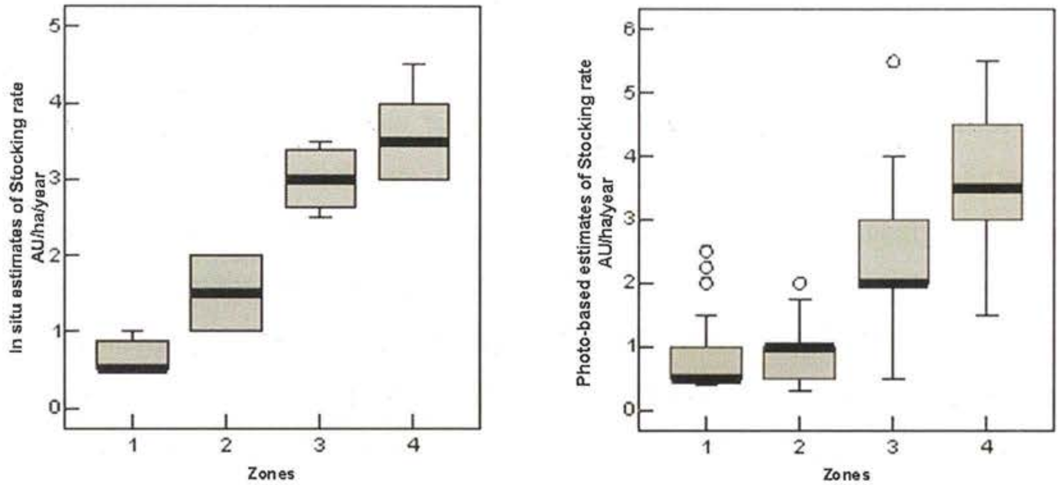
* and ° show the outliers for each zone.

* Mild outliers: cases with values between 1.5 and 3 box lengths from the upper or lower edge of the box (mildoutliers > Q1 - 1.5 IQR or mildoutliers < Q3+1.5 IQR but which are not extreme outliers).

° Extreme outliers: cases with values more than 3 box lengths from the upper or lower edge of the box (extreme outliers < Q_1 - 3 IQR or extreme outliers > Q_3 + 3 IQR).

The smallest and the largest non-outlier observations are represented by small horizontal lines linked to the box by a vertical line.

Figure 3.5. Boxplots showing the Distribution of Stocking Rate Estimates per zone given by the participants. (a) *In situ* and (b) photo-based estimates.



(a) *In Situ estimates for each zone.*

(b) Photo-Based estimates for each zone.

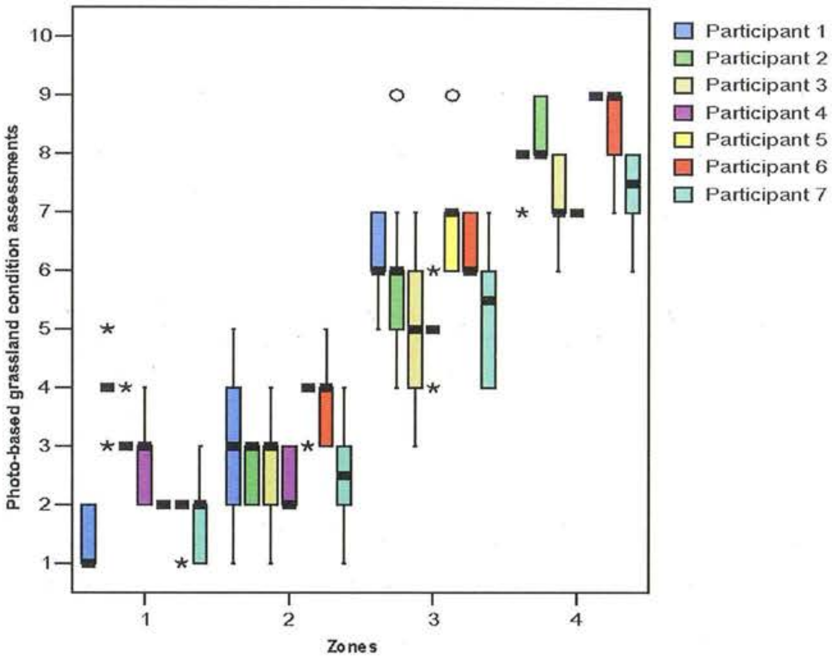
* and ° shows outliers. Further explanation of boxplot's figures is given in figure 3.4.

Nevertheless, the dispersion of the estimates is bigger in all the cases for grassland condition as well as stocking rate in the photo-based assessments. This could suggest that these assessments were more determined by the specific scene shown in each photograph and its representativeness of the corresponding zone. However, the dispersion of the estimates might also be influenced by the observer error. This is more evident on Figures 3.6 and 3.7, which show the distribution of responses to the photographs for grassland condition and stocking rate assessments respectively, per zone and per participant. The differences between the rating values given to the 10 photographs taken in the same zone are observed even in rating values given by the same participant in the majority of cases. Consequently, the results suggest that the use of a single photograph to represent a zone have to be seen with caution in the use of visual representation for grassland assessments. For instance, some researchers have made use of a single scene in rangeland evaluation guidebooks for further description of a specific zone under study (National Research Council U.S., 1962; Ottmar *et al.*, 1998; Ottmar *et al.*, 2004). Although this photograph provides to the user (e.g. local land user) a visual aid for a further comprehension of the information given in the guides, the researcher should take into account that the selected photograph shows only a partial representation of the study zone and so all visible elements of the studied rangeland could not be represented by this photograph.

In addition, with the objective to get further knowledge of the pattern of the assessments given by participants, that is, if assessments given to photographs taken in a same zone could be classified in a same group, a cluster analysis of the assessments of individual photographs was carried out. For this, a hierarchical cluster analysis using the method of nearest neighbour and a measure of squared Euclidean distance was performed with both types of assessment data, grasslands condition ratings and stocking rate estimates based on the individual 40 photographs (figure 3.8). The results show that despite the dispersion of the assessments of individual photographs among zones showed in figures 3.4, 3.5 and 3.6, the assessments could be classified in subgroups which are related to the zone where the individual photograph was taken. In turn, the cluster analysis of individual photographs based on stocking rate estimates reveals that the photographs from zone 4 were grouped in a well-defined cluster. This could suggest that the 10 photographs from the zone with best condition according to the participants (figure 3.4) were easier to make an estimation of their stocking rate. However, the photographs from the other 3 zones were less obviously grouped and hence the extension workers had less clear their estimation of stocking rate based on these photographs. These clusters could be related to the visibility and perception of the area necessary for such task as well as their experience in the estimation of such rate. It could be speculated that when the participant classify a photograph as representative of the best condition, the participant could tend to put the maximum number of animals which according to his opinion could be managed as stocking rate in the area. However, when the participant observes the photographs from the other zones, the sense of the area of the zone is limited and the estimates are not as definitive as the estimate of the maximum number to be included in the best condition zone.

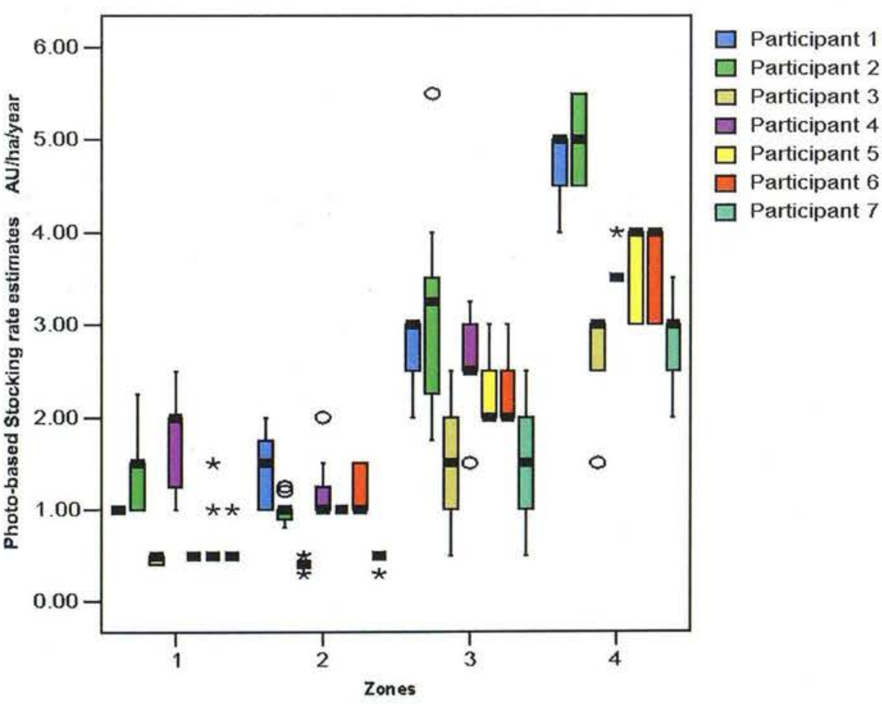
Moreover, the estimations of stocking rates given by the participants in this work were high in comparison with the ones reported by the study of IIP Qollasuyo (2005). Although there were found high correlation coefficients between *in situ* and photo-based estimates of stocking rate, further research is needed in order to get knowledge about the methodology that local advisers use to apply for these estimations in the study area. In addition, further research in the use of visible indicators in the study area that might guide the assessment of local land users is also important. Despite almost all participants of the present study did not give information about visible indicators used for grassland condition assessment, two of them reported that they base their assessment in the existence of some grassland species. For instance, for good conditions: *Festuca dolichopylla* and *Muhlenbergia* sp. and for the poor conditions the existence of some spiny shrubs. Although further research is needed in order to get knowledge about the local criteria and the visible indicators that local people use, the results show that the use of photographs is valid and reliable for the assessment of grassland in this context.

Figure 3.6. Distribution of Photo-Based Grassland Condition Assessments per Zone and Participant.



* and ° shows outliers. Further explanation of boxplot's figures is given in figure 3.4.

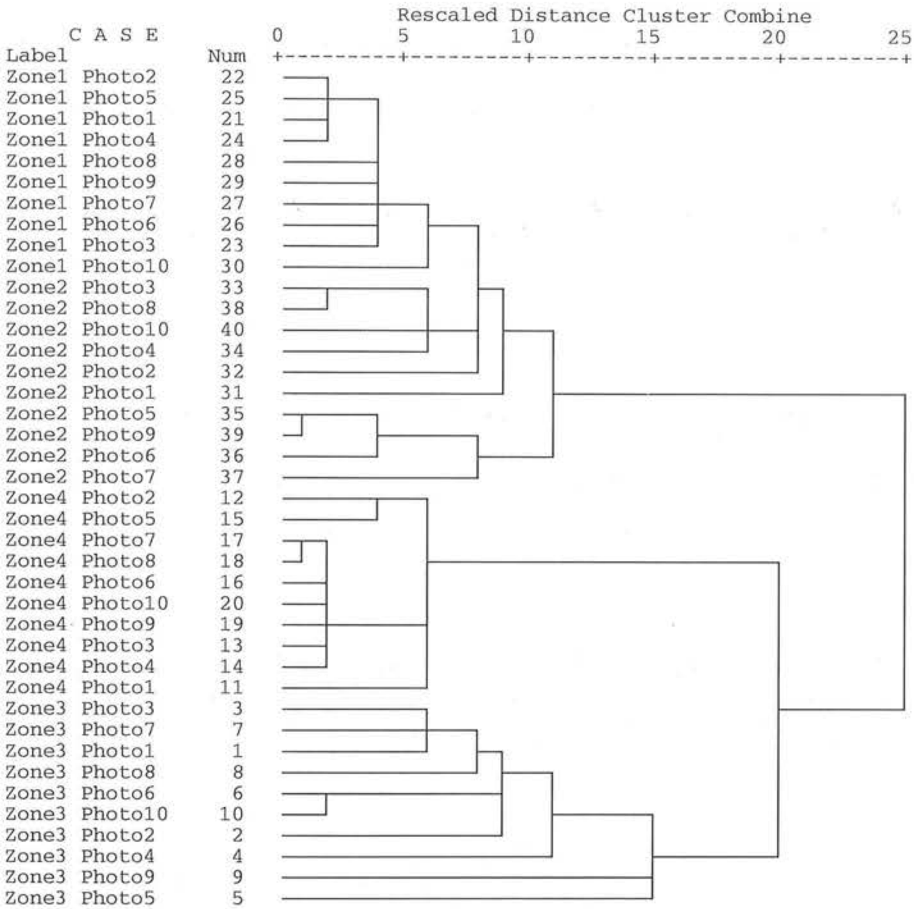
Figure 3.7. Distribution of Photo-Based Stocking Rate Estimates per Zone and Participant.



* and ° shows outliers. Further explanation of boxplot's figures is given in figure 3.4.

Figure 3.8. Cluster Analysis of Photographs based on (a) Grassland Condition Assessment and (b) Stocking Rate Estimates.

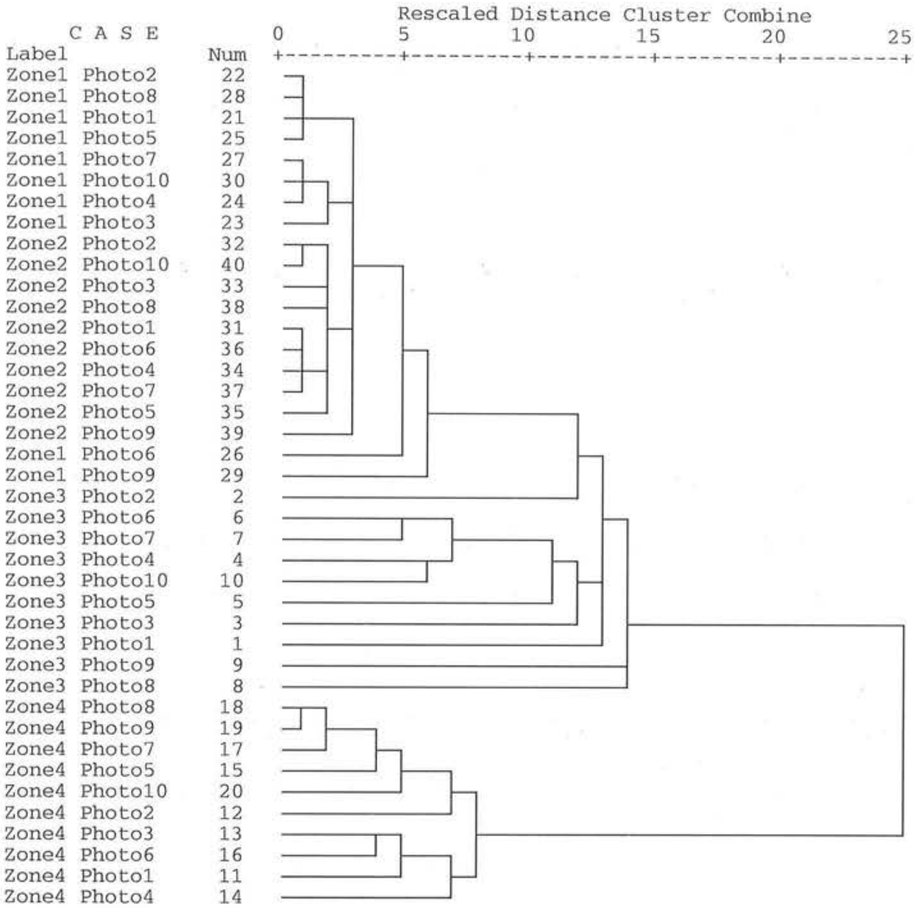
(a) Grassland Condition Assessments



Hierarchical Cluster Analysis, nearest neighbour, squared Euclidean distance

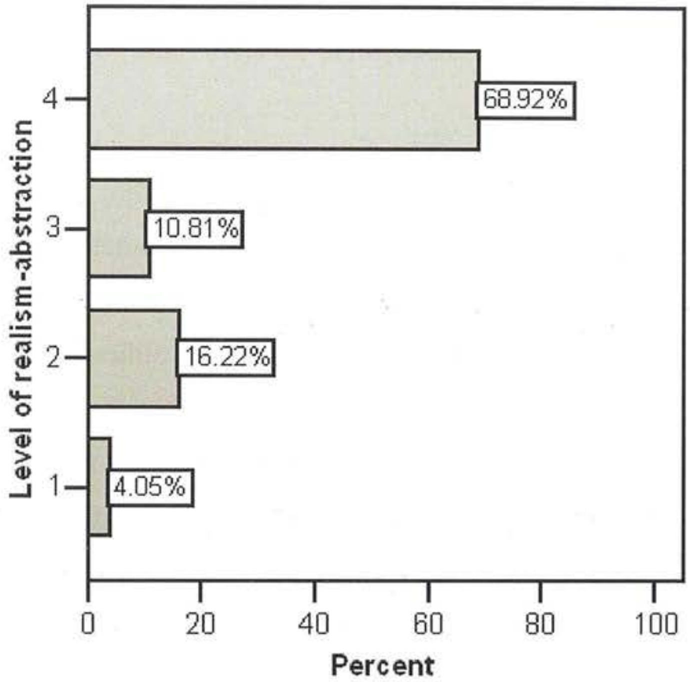
Figure 3.8. Continuation.

(b) Stocking Rate Estimates



Hierarchical Cluster Analysis, nearest neighbour, squared Euclidean distance

Figure 3.9. Percent of responses 'not possible to estimate' according to level of realism-abstraction.



3.6.3. *Realism-abstraction*

For this task, the participants were asked to assess the grassland condition and stocking rate for each image as in the previous task. Nevertheless, the answers to the stocking rate estimation were missing in 71.8% of the responses while for grassland condition assessment the missing values were 6.3% of the responses. It was not recorded by the participants if the absence of answers about stocking rate estimations was due to the fact that was not possible to estimate stocking rates using the images or due to another external factor. It could be speculated that the decrease of the realism of the representation affects the judgement of the viewer and decreases the possibility of visual evaluation for some tasks (in this case, for the estimation of stocking rates).

In a first exploration of the results about the assessments of grassland condition, it was observed that the 98.2% of the extension workers' responses based on the representative images of the fourth realism-abstraction level recorded that this type of representation could not allow an assessment of the grassland condition. In this sense, the results suggest that types of representations with high level of abstraction cannot be valid tools for being used in grassland management.

Taking into account all the responses given as 'not possible to assess' for all the level of realism-abstraction (figure 3.9), the highest percentage of this response was found in the fourth realism-abstraction level as it was previously mentioned (68.92% of all 'not possible to assess' responses found). It is followed by the second level (16.22%) and the third level (10.81%). In addition, the Correlation Coefficients between *in situ* assessments and the mean rating for the two photographs at each zone per each abstraction-realism level were also calculated. Without including the fourth level, the other three levels of abstraction realism present high correlation coefficients (0.947, 0.892, 0.922 for the first, second and third level respectively). It is also observed for the third level a higher correlation coefficient than the one showed for the second level. In this regard, these results suggest that the presence of colour is an important factor for the participants, at least, more than the detail lost at applying the facet filter, which makes an image look hand painted or an abstract painting according to the User Guide of Adobe Photoshop 6.0.

3.7. Conclusions

This paper shows results which give further knowledge of the validity of the use of visual representations for the assessment of concepts which are the base of usual decisions in grassland management (assessment of grassland conditions and estimate of stocking rates). As in scenic beauty, the reported results suggest that, in the field of grassland management, the use of visual representation as surrogates of the real environments show to be a reliable and a valid tool for the assessment of grassland condition and stocking rate. Nevertheless, the process of assessment done by the stakeholders in this study (extension worker group) takes into account different elements, which must be considered during the development of the visual material.

For instance, the inclusion of plant indicators could be relevant for the grassland assessment and must be taken into account for the visual representation of poor conditions. In turn, the estimates of stocking rates are less clear in photo-based assessments compared with the estimates done *in situ* suggesting than the sense of space (the estimation of the area of the zone) is an important characteristic for the visual assessment and visual representations oriented to support such estimates must include this characteristic.

During the selection of the specific tool for the implementation of the visual representation, it should take into account that high levels of abstraction do not provide valid representations for grassland assessment and hence for support in grassland management. In addition, the presence of colour in the visual representation is important for performing such task.

This exploratory study shows results that reveal the importance for the selection of the photographic material and the representativeness of the photographs. The use of a single photograph as representative of a complete zone could result in erroneous assessments of grassland condition and stocking rate of the zone and so, in the decisions influenced by this material in grassland and grazing management activities.

In summary, visual representations are valid tools for the support of grassland assessment by the group of extension workers. Nevertheless, these representations must include the base elements for their judgement, that is, high realistic images and visible grassland characteristics as well as an adequate representativeness of the visual material.

Further research is needed in the applicability of visual material for natural resource management in areas where aesthetic appraisal is not always the most relevant factor which guides the decision making process and the management of natural resources, especially if these representations are proposed to be valid support tools to target groups whose daily work is based on in-situ visual assessments.

3.8. Acknowledgements

The exploratory study reported in this paper was funded by the International Potato Center and the System Livestock Program, within the framework of the Virtual Laboratory on Systems Analysis in mixed Crop-Livestock Systems and as part of a PhD study funded by these institutions.

3.9. References

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Chapter 4

Comparing techniques of visual sampling in rangelands: Random versus participatory techniques[2]

4.1. Abstract

The study of people's environmental perceptions can be addressed by the use of visual material. In this regard, the visual sampling is a critical step for the success of this type of research: the photographic material has to be a representative sample of the environment and its visual elements across the spatial diversity. For these studies, two key factors have to be taken into account: the collected material that includes the visual elements which represent the objective physical characteristics of the study area, and the perceptual characteristics which can influence the observer criteria during a visual assessment. Besides the availability of some techniques for this purpose, the study of visual sampling has been neglected across the literature in comparison with other sampling methods for studying biophysical characteristics, e.g. vegetation attributes. The main goal of the present work is to compare common techniques used in visual sampling (a random technique, a participatory method and a mixed technique). The study is developed in six grassland areas of Junin department, located in the central mountain region of Peru. Results show that visual elements of photographs collected by different techniques may differ significantly. A comparison with indicators of grassland conditions shows that participatory techniques are more representative than the totally random method. This work stresses the importance of visual sampling (the selection of vantage points and scenes to be photographed across an study area) for collecting the visual stimuli (images shown to the participants) in studies of environmental perception.

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[2] Part of this research was presented in: Cruz, M., Quiroz, R. and Herrero, M. 2006. Comparing techniques of visual sampling in rangelands: Random versus participatory techniques. Poster presentation. American Association of Geographers Annual Conference: Chicago.

4.2. Introduction

The use of visual material for eliciting environmental perceptions of different human groups in studies of landscape assessment is a frequent practice (Daniel and Meitner, 2001; Kim *et al.*, 2003; Lekagul, 2002; Muñoz-Pedreros, 2004; Swaffield and Fairweather, 1996). In this field, in spite of the existence of new technologies for the visualization of natural scenes (Ervin, 2001; Lange, 1994; Schroeder and Orland, 1994; Tress and Tress, 2003), the use of photographic material is still the most frequent applied tool. This is due to its production facility as well as the related costs compared with other more sophisticated alternatives such as computer-based visual simulations. Nevertheless, a major difficulty in the use of photographic material for eliciting environmental perceptions is related to the fact that each photograph shows a restricted scene viewed from a vantage point of the zone to be represented. While the human vision manage an angle of 120° approximately, the photographs taken with standard cameras of 35 mm wide angle lens handle an angle of only 60° (Palmer and Hoffman, 2001). Therefore, there is suggested the use of several photographs for representing a zone in perceptual studies although this practice is not always followed when the visual material is collected. Indeed, the use of no more than one photograph per scenario under study is a common practice. For instance, in rangeland context, some researchers make use of the design of rangeland evaluation guidebooks in order to communicate their results to the local land user or to other researchers (e.g. National Research Council U.S., 1962; Ottmar *et al.*, 1998; Ottmar *et al.*, 2004). For this, the guidebooks provide biophysical information collected in study areas as well as a view of the zone (i.e. photograph), which help to compare the studied areas with other similar areas of interest of the land user.

Hull IV and Revell (1989) gave attention to the importance of the scene sampling for visual quality studies, which is one of the first critical steps for the success of the research that involves a photographic sample for representing the area under study.

However, the research of visual sampling has received only modest subsequent attention. This fact is surprising considering the effort given to other sampling methods for studying biophysical characteristics, e.g. vegetation attributes (USDI BLM, 1996).

The aim of the photographic sampling for environmental perception of real environments is to get the photographs which are representatives of the scenarios under study (e.g. landscape or natural scene). In contrast with the other sampling approaches of biophysical characteristics, the selection of photographic material in visual sampling under this context must include not only the visual elements which represent the objective physical characteristics of the study area, but also the perceptual characteristics which could influence the observer criteria during a visual assessment. During the process of visual sampling, two main decisions are related to the selection of the scene to be captured by the photograph. The first one is to decide the location from where to take the scene (the vantage point) and the second one is to choose the specific direction and what to look at from that vantage point. Across the literature, the selection of the vantage points constitutes the more variable characteristic between the different applied techniques. The specific way to locate the camera in each vantage point is usually determined by the target person (i.e. photographs are taken horizontally at the eye level of the observer using a tripod). According to this, the different techniques can be divided by the criteria applied for the selection of the vantage points: the ones which include some degree of randomness for the location of the vantage points across the study area and the ones which include a participatory selection for the decision of locating the vantage points (e.g. asking people to choose the representative locations according to their criterion) (Hull IV and Revell, 1989). In the former, the random issue is managed according to the objective of the study. For example, the vantage points can be located using a random method within a spatial area (Anderson and Schroeder, 1983; Buhyoff *et al.*, 1986; Daniel and Boster; 1976) or using a random selection of points following a specific path (e.g. a road) (Evans and Wood, 1980; Schroeder and Daniel, 1980). On the other hand, the latter approach involves the addition of subjective assessment from a human group (e.g. a set of experts in the field or local people) (Fines, 1968) for the scene selection in order to ensure the incorporation of the landscape features which are thought representative and relevant for the perceptive assessment. For example, the participation of local managers of grassland areas (e.g. shepherds) in the identification of the scenes to be photographed could link the scenes to the visible indicators used by this human group for their perceptual judgement. Indeed, the use of visual material in participatory livestock research is promoted not only for the collection of local knowledge but also for increasing the involvement of the local human groups in the research (Conroy, 2005).

This paper compares the application of three different approaches applied in visual sampling (a random technique, a participatory method and a method which involves a mixture of both criteria). The focus of this study is based on the sampling of grassland areas. This is due to a subsequent use of the photographic material for examining the perception that local people have about grassland areas under different conditions.

4.3. Study area

The study was carried out in the grassland area of Junin department, located in the central mountain region of Peru, during 2003 and 2004. This area is managed by the Sociedad Andina de Inversiones Sub-Regionales (SAIS, i.e. Andean SubRegional Investment Association) Pachacutec, which groups seven rural communities across the region (Carampoma, Huaypacha, Yantac, Mitma, Laraos, Huanza and Cullhuay). Its human population depends mainly on economic activities related to livestock management and land management for grazing. For this, the SAIS Pachacutec manages native high-Andean grasslands in five production units (Corpacancha, 42459 ha; Santa Ana, 20132 ha; Conocancha, 6298 ha; Cuyo, 2600 ha; Capillayoc-Oxamachay, 14436 ha; which are owned by its associate rural communities) and nearly 92,500 livestock animals (ovine, 83.86%; bovine, 6.5%; alpacas, 8.71%; llamas, 0.43%; equine, 0.49%; and porcine, 0.02%) (SAIS Pachacutec SCRL, 2002). Further information about the study area can be found in the next Chapter (Cruz *et al.*, 2007).

4.4. Material and Methods

4.4.1. Selected zones

Six zones were selected in order to have a representation of the different grassland conditions found across the study area. The altitude of selected zones ranged between 4029 m and 4557 m above sea level (Ordemal: 373130 E, 8744379 N, Chicrawain: 367513 E, 8750699 N, Tinyac: 367355 E, 8748855 N, Kuspicancha: 371360 E, 8744317 N, Yanacocha: 355848 E, 8747918 N, Ranramachay: 361985 E, 8747228 N). This selection was performed through the discussion with local people (SAIS' administration and shepherds) as well as researchers who had wide experience working in the study area. For this, multiple meetings were carried out with members of local population (administration and shepherds) as well as exploratory trips with researchers working in the study area. The inclusion of the participation of the latter group (researchers) was especially of interest for this study because their work involved the data collection for the publication of an inventory of grasslands in the SAIS Pachacutec. Although this inventory was not finished at the time of the present study, the researchers gave references to areas with different conditions already assessed by that team. Two main characteristics were taking into account as the main criteria for the selection, the representation of the different grassland conditions commonly found in the SAIS and the accessibility to these zones. Afterwards, the herbaceous biomass production in the selected zones was estimated using the Comparative Yield Method developed by Haydock and Shaw (1975) and the species composition was evaluated by the dry-weight-rank method devised by t'Mannetje and Haydock (1963) and improved by Jones and Hargreaves (1979).

In the Comparative Yield Method, first, a set of reference plots are subjectively located by a group of researchers. The selection of these reference plots has the objective to represent the yield that is expected to be commonly encountered across the study zone. In this study, plots of circular shape ($a=0.25m^2$, $r=0.39m$) were used for increasing the area:boundary ratio of the plot (Bonham, 1989). A selection of five reference plots (a five-point scale from the lowest to highest, 1 to 5, levels of herbage amount) for each zone was done by a team of 4 people. The selection of the reference plots was based on visual assessments of herbage amount within the circular shape. A plot which could represent low yielding situations was selected. This plot became standard 1. In the same way, a plot which could represent high yielding situations was selected (standard 5). Next, having as reference both plots (standard 1 and standard 5), a plot that represents a middle point in herbage amount was selected to be standard 3. Following this comparative method, plots of standard 2 and standard 4 were selected. As a result, the reference plots were unique for each zone. That is, a plot selected to be standard 5 in a zone might not be equivalent to a plot selected to be standard 5 of a different zone because different zones might have different high yielding situations.

Afterwards, once the researchers were confident of their ability to rank other plots according to this scale (from 1 to 5) by comparison with the reference plots, a subsequent random sampling of additional plots is performed across the zone. In the present study, the sample size of visual estimations (additional plots) per zone was 30. Finally the vegetation (segregating by species for each zone) of the reference plots was clipped, the harvested herbage were oven-drying at 100° C and weighed. The five dry-weights of the reference plots were used to calculate a regression equation. The estimation of the dry-weight of herbage in each zone was calculated by substituting the average rank of the sample of the zone ($\bar{x}_{\text{sample}}$) in the regression equation estimated for that zone (figure 4.6).

In turn, to apply the dry-weight-rank method (t'Mannetje and Haydock, 1963; Jones and Hargreaves, 1979) in the present study, the team of 4 people visually identified the first, second and third most abundant species (ranks 1, 2 and 3) within each plot. When there were only two species, the most abundant species was assigned to the ranks 1 and 2 and the second most abundant species was assigned to the rank 3. In the same way, when there was only one species, this was assigned to the ranks 1, 2 and 3 within the evaluated plot. This estimation was carried out for the 30 sample plots. Afterwards, the ranks were tallied for each species and weight by a set of multipliers (0.70 for rank 1, 0.21 for rank 2 and 0.09 for rank 3). This set of multipliers were derived by t'Mannetje and Haydock (1963) and subsequently tested by some researchers (e.g. Dowhower *et al.*, 2001; Mazaika and Krausman, 1991; Neuteboom *et al.*, 1998). The resulting weighted values are added for each species and the result multiplied by 100 in order to express the species composition in percentage (figure 4.5).

The comparative yield method and the dry-weight-rank method have been applied for purposes of rangeland inventory and monitoring of range condition by several researchers (e.g. Despain and Smith, 1989; Friedel *et al.*, 1988). Although information about some factors participating in environmental degradation was not available for the selected zones (e.g. grazing intensity or fire regime) (Behnke *et al.*, 1993; Sivakumar, 1992), the estimation of total biomass and species composition provided to the study information about the characteristics of the vegetation at the time of the collection of the photographic material in each zone.

4.4.2. Visual sampling techniques

A photographic sampling was performed within the six selected zones. Each photograph was taken with a digital camera (focal length: 4.4 mm) with a resolution of 1600 x 1200 pixels and using a tripod (height: 1.70m, with spirit level), horizontally at the eye level of the observer. The photographic material for this study was based on 24 photographs (4 per each selected zone) for each technique applied. This number was selected taking into account the objective of photographic sampling in the study context: the construction of a visual questionnaire for eliciting environmental perceptions (i.e. in this work, this was mainly related to the grassland condition for grazing management). In this sense, the selected number of photographs was chosen taking into account the restriction of the available time for interviewing the target local people as well as trying to avoid a photographic survey which could be cognitively overwhelming. Three techniques for visual sampling were applied and compared in this study. For the first two techniques applied, a photographic collection was performed in each zone along walks through each zone

(Daniel and Boster, 1976). The direction of the scene was randomly chosen based on the 360º given by the use of the tripod. The first technique applied for obtaining the photograph sample was based on the random selection of 4 photographs per zone from the previous gathered photographic collection. In turn, the second technique also used the photographic collection but the selection of the 4 photographs per zone was based on a participatory approach. For this, a person pointed as skilled in the study area was asked to select the 4 photographs per zone which could be the most representative photographs of that zone according to his opinion. The selection of this person was based on the collected comments across the local population and the administration about who had major knowledge of each zone. In this regard, the person assigned for this task was the shepherd in charge of the paddock or alternatively, a shepherd assigned by the administration who was familiarized with the zone and the grazing management work within it. Finally, for the third technique, the participant was asked to select a vantage point within the zone from where four representative photographs of the zone could be taken rotating the camera. The first photograph was taken randomly within the 360º based on the use of the tripod and the others were taken at 90º, 180º and 270º from the first one rotating the camera in same vantage point (Daniel and Boster, 1976). Figures 4.1, 4.2 and 4.3 show the photographs taken through the use of the three techniques.

Figure 4.1. Photograph sample using technique 1 (random technique).

Figure 4.2. Photograph sample using technique 2 (selection by participant).

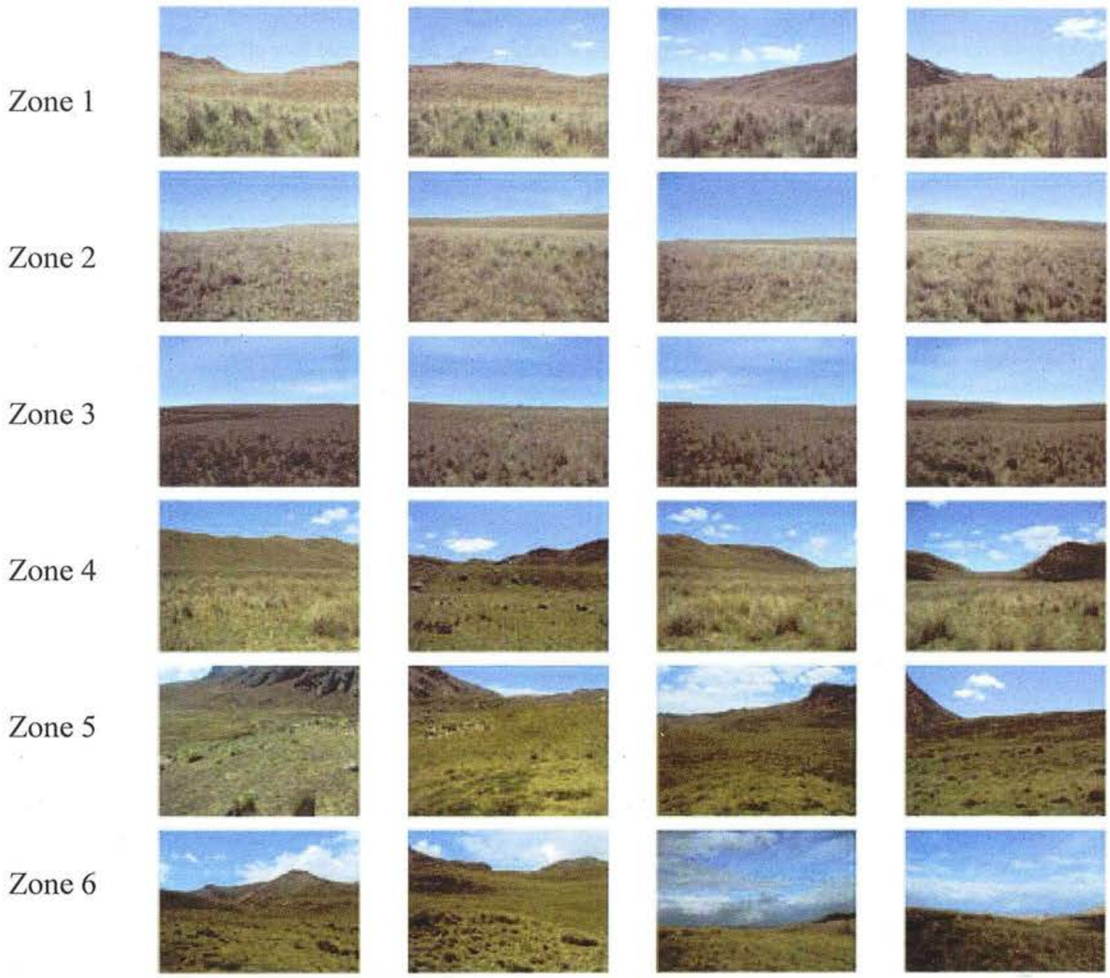
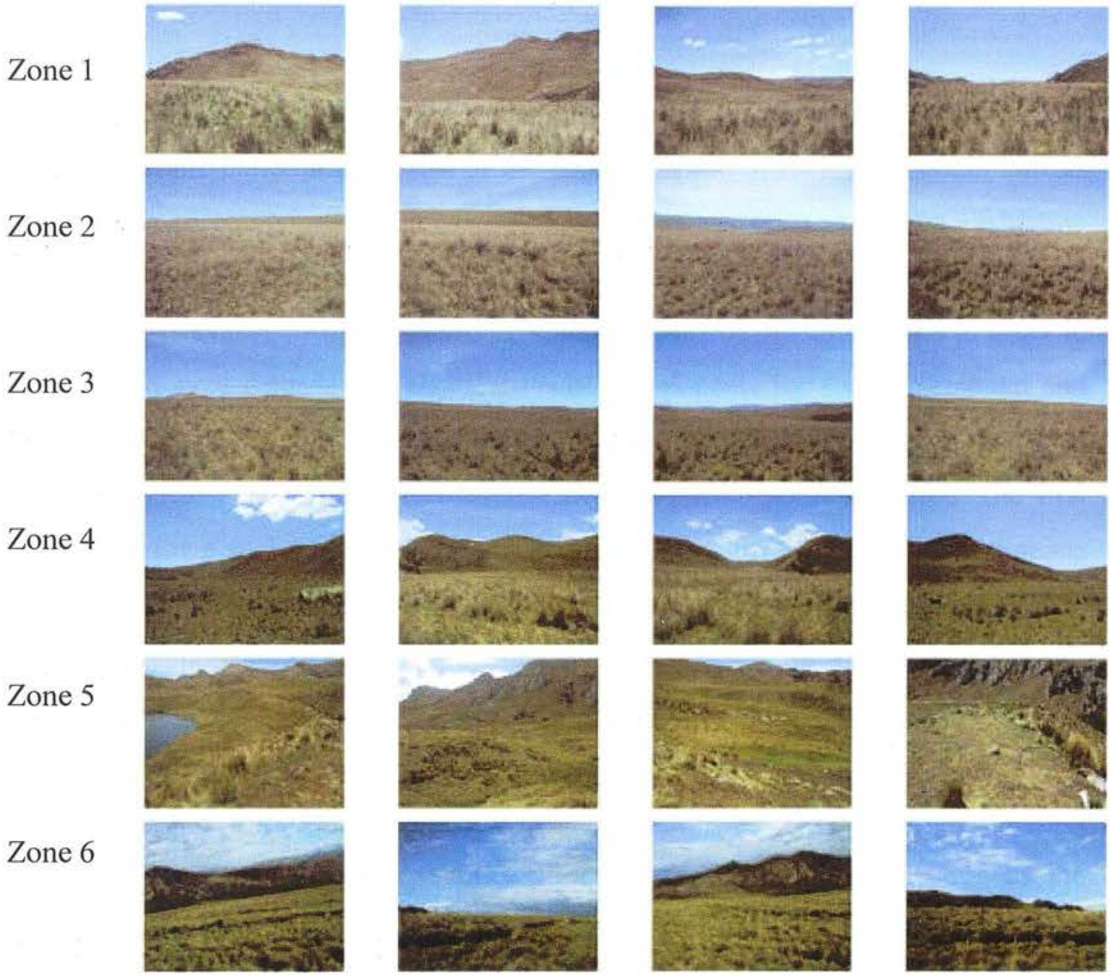


Figure 4.3. Photograph sample using technique 3 (selection of the vantage point by the participant and rotation of the camera for taking 4 photographs).



4.4.3. Comparison using physical-visual components recorded in the photographs

Previous studies developed for the research of people's preferences through the use of photographic material make use of the decomposition of each photograph into its physical-visual components (Kim *et al.*, 2003; Misgav, 2000). After the evaluation stage where the combination of the different physical components showed in each photograph is evaluated by the participant, there is carried out an analysis in order to identify the most determinant physical-visual components for such assessment and the criteria used by the viewer. In this context, the present work applied two methodological approaches for characterizing the photographic material. The first one broke down each photograph into a group of main physical-visible components (table 4.1a) and the proportion that each component has in each photograph. For this, physical components of each scene were measured by counting numbers of pixels using the Adobe Photoshop Software Program and the area of each component was converted to the proportion of the total area in the photograph (Kim *et al.*, 2003). The second approach applied a photograph characterization based on interviews among four local workers who were familiar with the study area. The selection of the workers was carried out by interviewing with the administration personal and shepherds working in the study area. The participants were asked to describe the different physical-visual components shown in each photograph. According to this, there was elaborated a list of physical characteristics (table 4.1b) which served as a collection of elements upon which evaluation of each photograph would be based. Next, the participants were asked to revaluate the presence of these characteristics according to the proposed alternatives (Misgav, 2000). The results of their assessments and the degree of agreement among the participants for evaluating each characteristic were examined using reliability statistics, which showed a high level of agreement among evaluators. The most frequent value given to the characteristic by the 4 participants was recorded due to the data type and used as basis for subsequent comparison among samples collected by different visual sampling techniques.

Table 4.1. Physical-visual components for the characterization of the photographs.

(a) Indicators measured through the use of Adobe Photoshop program

Components	**Criteria**
Sky	Area of the sky in the photograph
Mountains	Area of the mountains in the photograph
Hills	Hill area
Paddock area	Total area of paddock
	Soil without grassland
	Low grassland
	Middle/High grassland
	Rocks
Water	Area of water in the photograph

(b) Indicators assessed by participants

Components	Criteria	Quality
Paddock area	Predominant cover	Undetermined; Only grasslands; Combination (area with grasslands and without grasslands)
	Grassland height	Undetermined; High; Medium; Low
	Grassland color	Undetermined; Green; Yellow; Combination
	Stony	Undetermined; None; Scare; Regular; Abundant
	Presence of fence	Undetermined; Yes; No
Hill	Presence of hills	None; One hill; Several hills
	Location of hills	No mountain; Near; Far
	Hill cover	Undetermined; Only grasslands; Combination
Mountains	Presence of mountains	None; One mountain; Several mountains
	Location of mountain	No mountain; Near; Far
Water	Presence of water (lagoon, lake or other large body of water)	Undetermined; Yes; No
	Presence of irrigation ditch	None; Dry; With water
Animals	Presence of animals	Yes; No
Road	Presence of road	Yes; No

The components listed in table 4.1 were only based on the visible characteristics shown in the photographs. In this regard, the instruction for the characterization was to list the visible elements only shown in the photographs and in no other information that the participant could 'remember' from the real zone.

4.5. Results

4.5.1. *Biomass production of the selected zones*

The herbaceous biomass production was estimated for having a reference of the pasture yield in each one of the visual sampled zones (figure 4.4). The total dry-weights of herbage obtained from the reference plots were plotted against the visual assessment ranks given for the same reference plots and a regression analysis performed. As is shown in the figure 4.6, the data did not follow linearity so an exponential equation was used. The biomass production of each zone was calculated by interpolating the visual estimates of the sampling plots in the obtained calibration equation for each zone (as explained in previous section). In addition, the species composition calculated using the dry-weight-rank method (Jones and Hargreaves, 1979; t'Mannetje and Haydock, 1963) is shown in Figure 4.5.

Figure 4.4. Total estimated dry-weights (kg/ha) of herbage per zone.

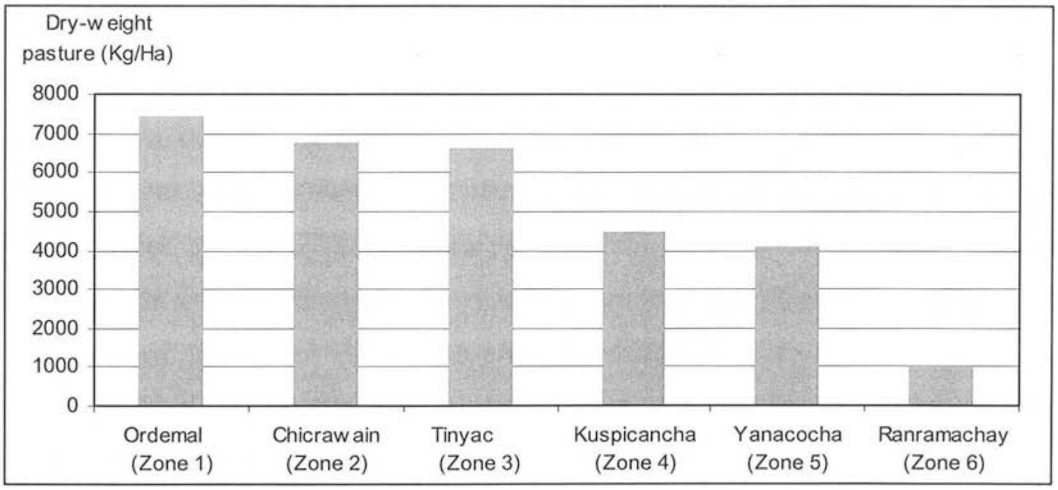
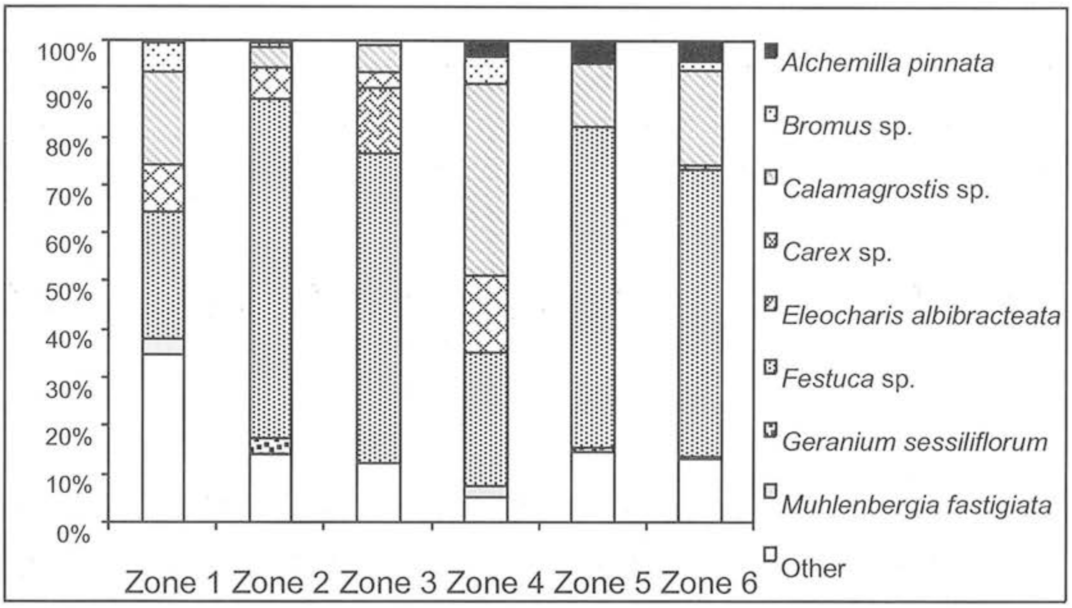
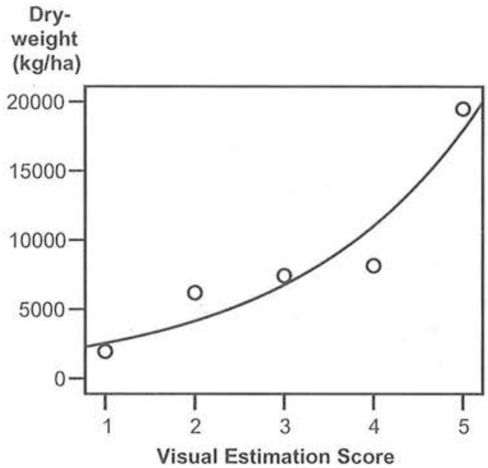


Figure 4.5. 100% Stacked column of species composition per zone calculated by dry-weight rank method.

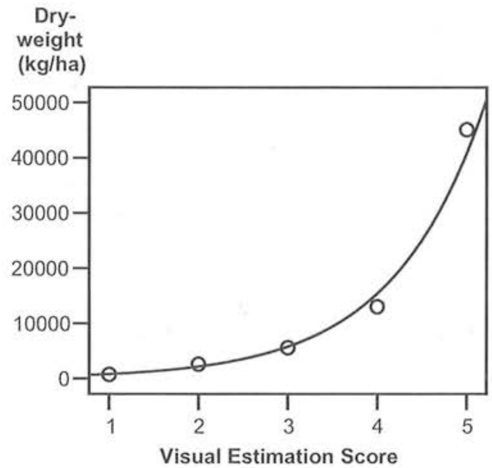


The zones under study were sorted according to their estimated dry-weights of herbage and labelled according to their position in this order for further comparison with the visual samples (zone 1: Ordemal; zone 2: Chicrawain; zone 3: Tinyac; zone 4: Kuspicancha; zone 5: Yanacocha and zone 6: Ranramachay). Results showed that the selected zones presented differences of the quantity and diversity of vegetation. The predominant species in all the zones were *Festuca* sp. and *Calamagrostis* sp. The estimated herbaceous biomass production ranged from 7416 kg/ha (zone 1, Ordemal) to 975 kg/ha (zone 6, Ranramachay).According to Florez *et al.* (1992), the type of livestock in the study area (i.e. sheep) prefers to eat the species *Hipochoeris taraxacoides*, however, if this species is absent in the zone, as it was during the time of the present study, *Muhlenbergia* sp. is used by the sheep in this Andean area. Other species, such as *Calamagrostis* sp. and *Astragalus garbancillo* are only eaten if the zone is overgrazed and the previously mentioned species are not present. In the study area of the present study, *Muhlenbergia fastigiata* was only found in Zone 1 and Zone 4 while *Calamagrostis* sp. was found in all zones. The major variability of species composition was found in Zone 1 followed by Zones 2 and 3.

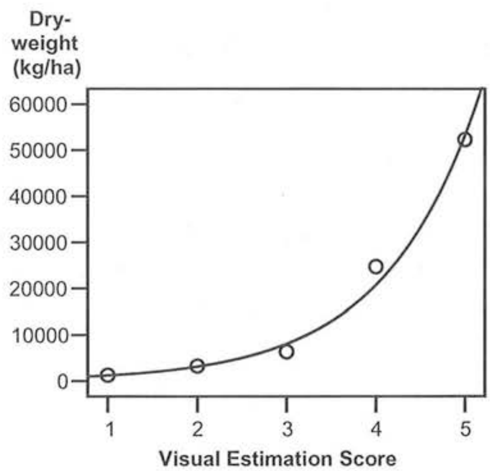
Figure 4.6. Measured dry-weights against the visual estimates scores of the reference plots and the corresponding exponential equation for each zone.



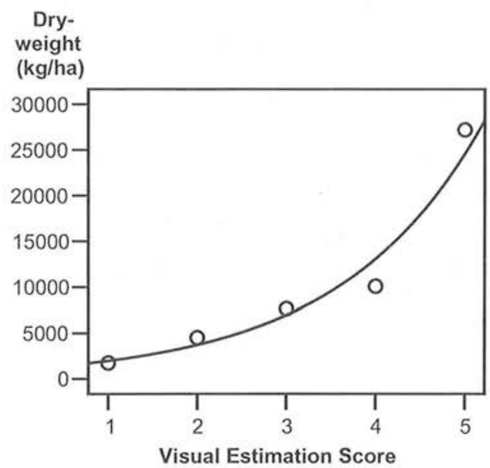
Zone 1, Y=1571.18($e^{0.4872x}$),r^2=0.88,$\bar{x}_{sample}$=3.18



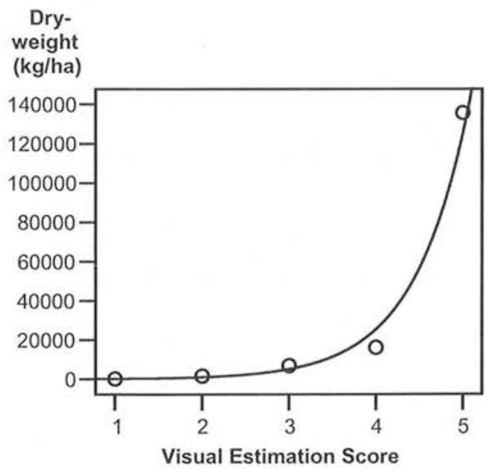
Zone 2, Y=314.539($e^{0.9733x}$),r^2=0.99,$\bar{x}_{sample}$=3.14



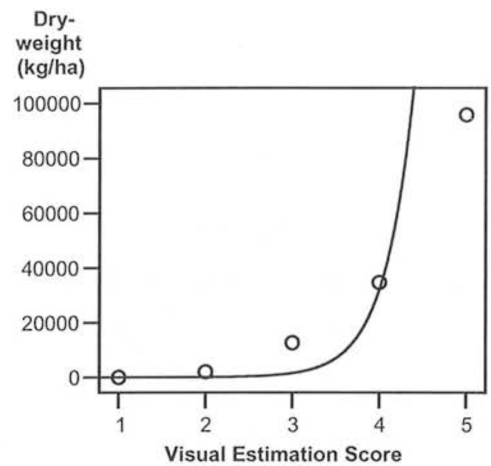
Zone 3, Y=480.564($e^{0.9418x}$),r^2=0.99,$\bar{x}_{sample}$=2.77



Zone 4, Y=1052.05($e^{0.6303x}$),r^2=0.97,$\bar{x}_{sample}$=2.29



Zone 5, Y=43.5214($e^{1.5930x}$),r^2=0.98,$\bar{x}_{sample}$=2.85



Zone 6, Y=0.1676 ($e^{3.0397x}$),r^2=0.68,$\bar{x}_{sample}$=2.85

4.5.2. *Proportion of the main physical-visible components*

Multiple Multivariate Analyses Of Variance (MANOVA) and post-hoc tests were performed per zone. The goal of this task was to examine if the photographs acquired by the application of the three visual sample techniques registered similar area proportions of the main physical-visible components (sky, mountain, hill, paddock and water). The results of the MANOVA analysis (table 4.2) of these variables suggest that the visual sampling techniques registered similar area proportions of these general components in 3 of the 6 zones under study (zones: 2, 3 and 4). However, in the other half, there were significant differences in at least one mean of the component proportions. These differences were observed in the mountain and paddock area for zone 1, hill and paddock area for zone 5 and mountain area for zone 6. The results suggest that the characteristics of the zone should be taken into account when selecting the methodology to use for visual sampling. When random methods are used for visual sampling, the vantage point might be located in areas were the visibility is blocked by different elements of the landscape (e.g. tall vegetation). In the present study, the selected zones shared the characteristics of the ecosystem of high grassland areas of the Peruvian central mountains. Despite this, the slope of the paddocks where the photographs were taken was low. However, these were not totally flat and small differences in the slope might also affect the impression that the viewer has of the size of the closest elements to the position of the camera. For instance, differences in the slope of close areas to the location of the vantage point might give a misleading impression of the vegetation. Since the camera angle was always constant in the present study, horizontally to the eye of the viewer, differences of the proportion of elements of the landscape (e.g. paddock area) could be increased or decreased by differences in the slope of close areas to the camera.

Post hoc tests were carried out with the objective to determine which means of these variables related to the use of different visual sampling techniques differed. Scheffe's test and Tukey HSD test showed similar results. For the zone 1, both tests displayed significant differences in mountain area and paddock area between techniques 1 and 2 and between techniques 1 and 3 ($P<0.05$). For the zone 5, the tests also showed significant differences in hill area between means related to techniques 1 and 2 as well as techniques 2 and 3. In addition, differences in means of paddock area proportions related to techniques 1 and 3 were found. Finally, for zone 6, significant differences were found between means of mountain area proportions related to techniques 1 and 3. In these cases, technique 1 gave the higher proportions of mountain area in the photographs, the lowest proportions of paddock area and hill areas. On the other hand, technique 3 gave higher proportions of paddock area and the lowest proportion of mountain area. These effects were found across zones.

Table 4.2. MANOVA of main physical components among photographic samples obtained by the three different techniques of visual sampling.

ZONE		VARIABLES				
		Skyarea	**Mountainarea**	**Hillarea**	**Waterarea**	**Paddockarea**
Zone 1	F	1.959	21.173	3.411	.	9.303
	Sig.	0.197	0.000	0.079	.	0.006
Zone 2	F	1.493	0.431	0.232	.	1.801
	Sig.	0.275	0.662	0.798	.	0.220
Zone 3	F	1.237	1.389	0.589	.	1.941
	Sig.	0.335	0.298	0.575	.	0.199
Zone 4	F	1.439	0.554	0.522	.	.147
	Sig.	0.287	0.593	0.610	.	0.866
Zone 5	F	2.943	2.809	11.373	1.769	4.488
	Sig.	0.104	0.113	0.003	0.225	0.044
Zone 6	F	0.033	5.185	0.826	0.519	2.055
	Sig.	0.968	0.032	0.468	0.612	0.184

* Degrees of freedom: Between groups = 2, Within groups = 9, Total = 11

Also, Multiple Multivariate Analyses Of Variance (MANOVA) and post-hoc tests were performed per zone for the variables which take into account the characteristics within the paddock where the photographs were taken. The results (table 4.3) showed significant differences in the record of grassland size in zone 3 and zone 6 (variables: low grassland and middle/high grassland). For zone 3, post hoc tests (Scheffe's test and Tukey HSD) showed significant differences among the collected material by all the different techniques (significant differences between techniques 1 and 2, between techniques 1 and 3, and between techniques 2 and 3). For zone 4, post hoc tests showed significant differences in the comparisons that involved the technique 1 (significant differences between techniques 1 and 2 and between techniques 1 and 3).

Hence, these results suggest that the different techniques of visual sampling do not necessarily collect visual material which show the same main physical-visible components examined. This may be viewed with special care for the application of the technique 1 of visual sampling under study (the random technique), which may record different components compared to the other two visual sampling techniques.

Table 4.3. MANOVA of physical components in the paddock area among photographic samples obtained by the three different techniques of visual sampling.

ZONE		VARIABLES			
		Soil without grassland	Low grassland	Middle/High grassland	Rocks
Zone 1	F	.	1.009	1.330	0.728
	Sig.	.	0.402	0.312	0.509
Zone 2	F	.	0.962	0.954	0.308
	Sig.	.	0.418	0.421	0.743
Zone 3	F	.	171.420	147.604	1.132
	Sig.	.	0.000	0.000	0.364
Zone 4	F	1.000	0.242	0.234	0.680
	Sig.	0.405	0.790	0.796	0.531
Zone 5	F	0.261	1.629	1.673	1.690
	Sig.	0.776	0.249	0.241	0.238
Zone 6	F	1.955	10.933	11.779	0.251
	Sig.	0.197	0.004	0.003	0.7874

* Degrees of freedom: Between groups = 2, Within groups = 9, Total = 11

Based on the proportion of the paddock area shown in the photographs.

The results in the previous section showed differences in the herbage yield among the different zones. It could be expected that the presence of tall grasses decrease as the presence of short grasses increase. Figure 4.7 shows the proportion (mean of the 4 photographs per zone) of areas with short and tall grasses (proportion of the paddock area and not the total area of the photograph). These results suggest that among the three techniques, the one which followed this tendency is the technique 3 (mixed technique), followed by technique 2. The random technique did not register this characteristic across its photographic material.

4.5.3. Characterization of components by participatory approach

Figure 4.8 shows the results obtained from the characterization of each photograph by the participants according to the components referred in table 4.1b. The differences among the visual samples of the three techniques were marked using this type of characterization. The nominal data revealed the absence of different components which could be used by the participants as preference indicators. Preliminary interviews with some representatives of the local population give some clues related to the possible indicators that they might use for visual assessment. For example, there were mentioned the presence of water, grassland cover, height and color and the presence of animals in the area. If so, the different techniques did not register all the perceptual elements which might be important in the viewer's criterion for visual assessment.

Figure 4.7. Proportion (mean) of grassland areas according to their size by zone and technique.

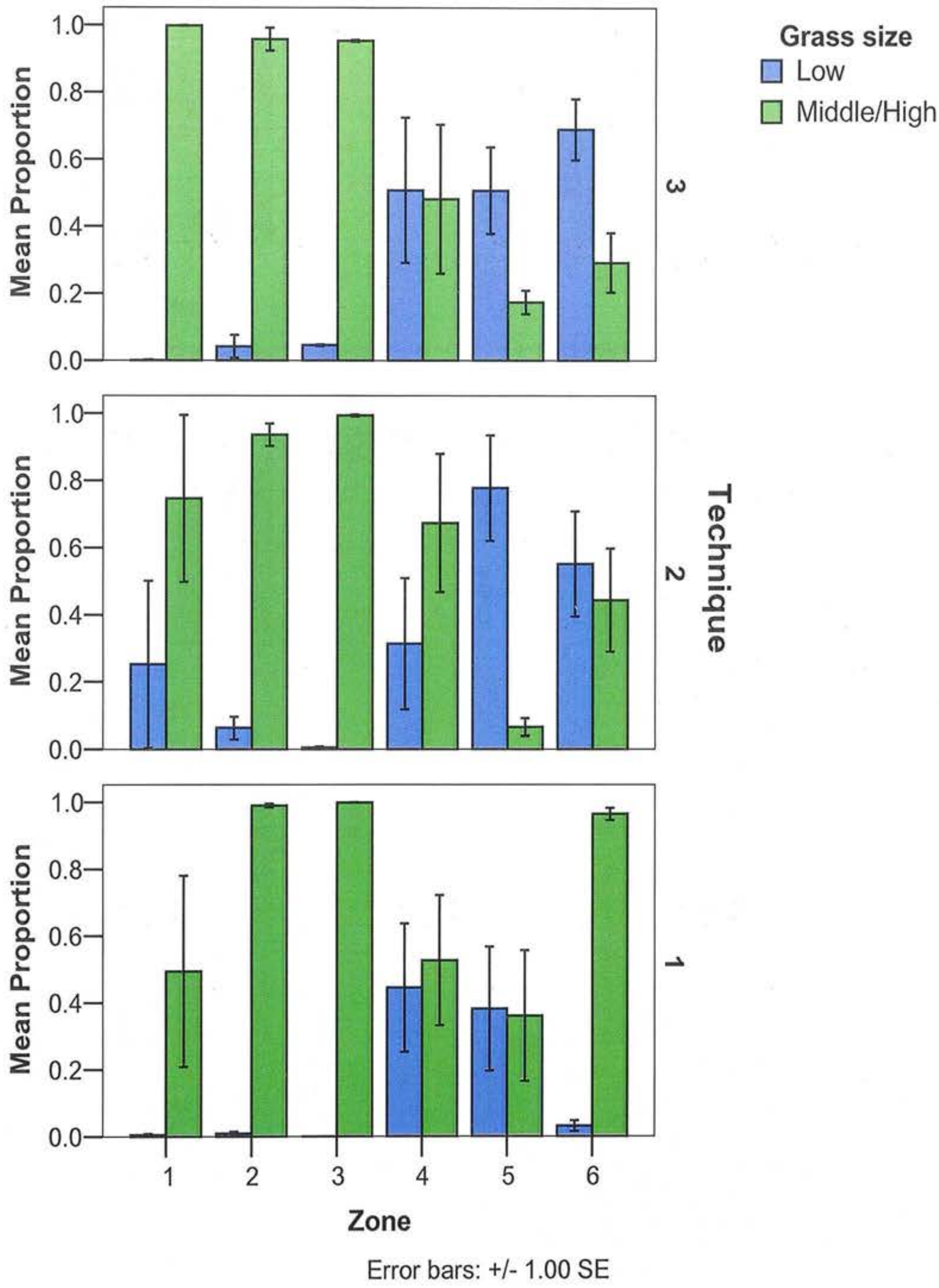
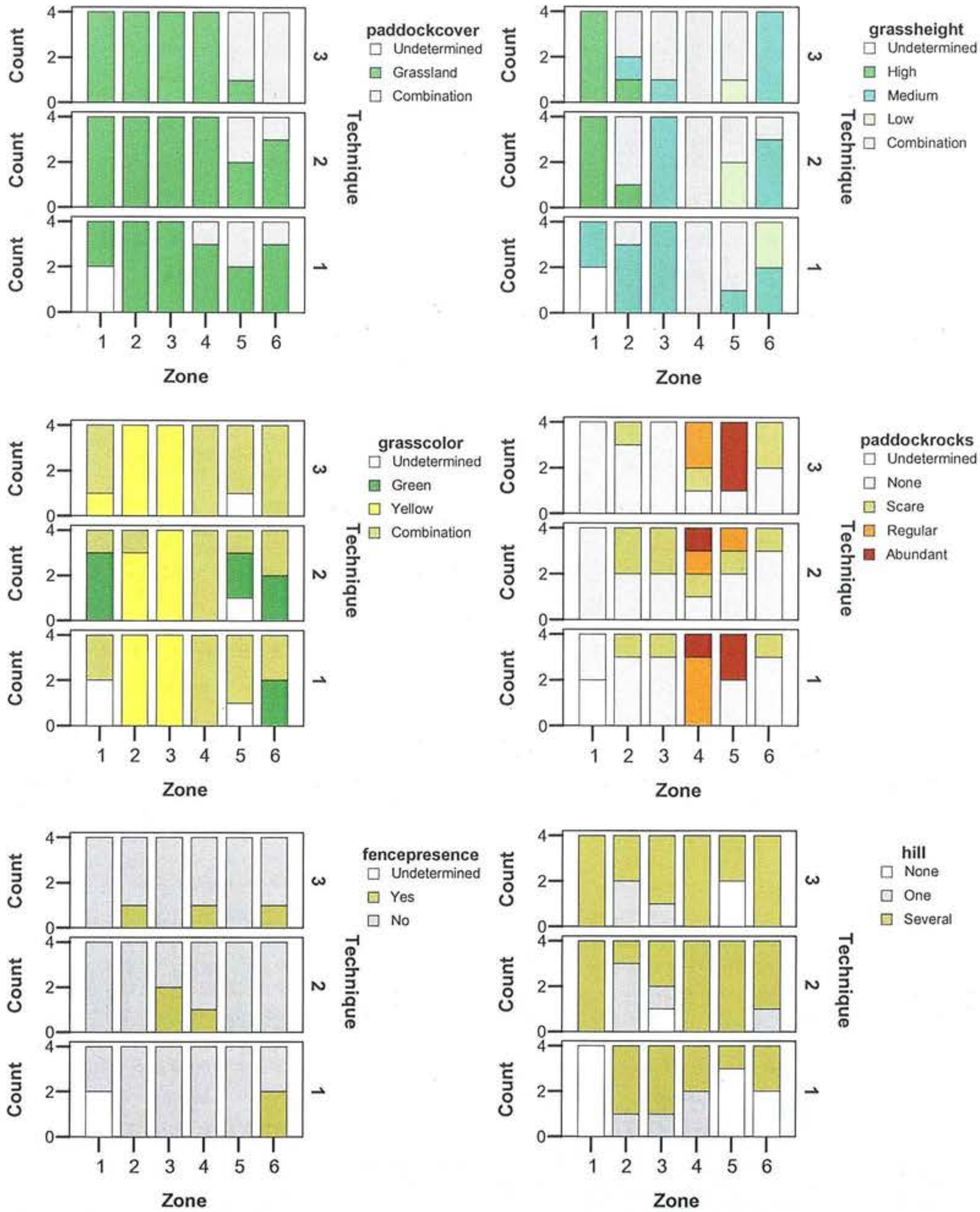
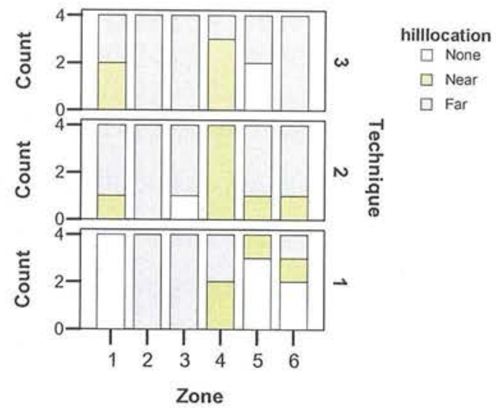
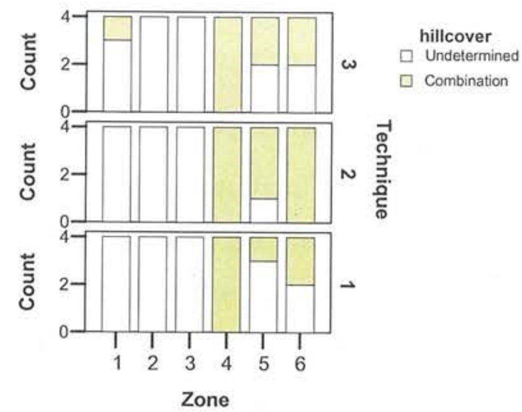
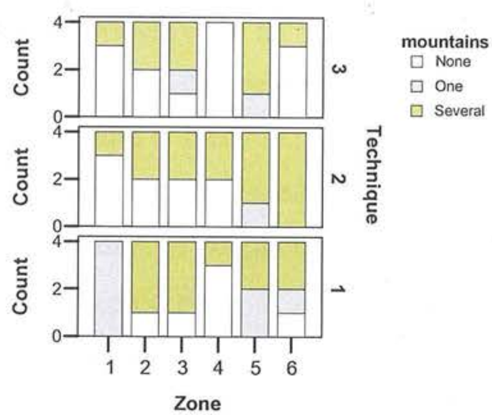


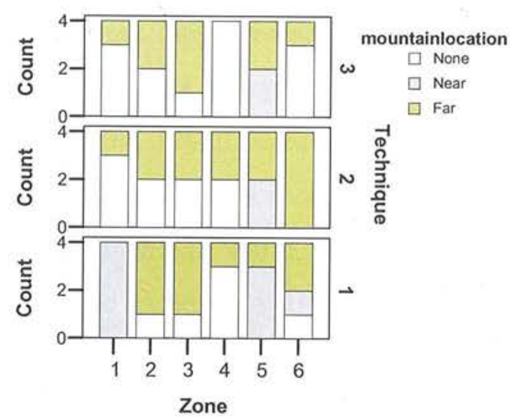
Figure 4.8. Stacked bar of presence of components evaluated by participants (counts of photographs by zone and technique).

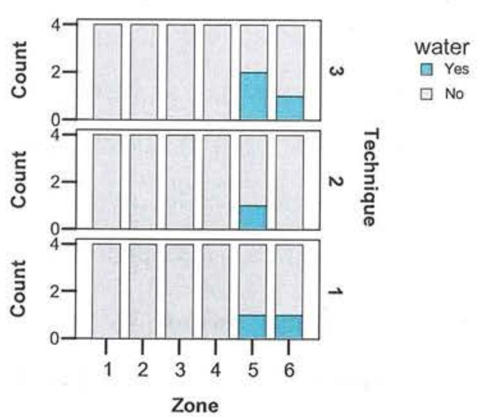


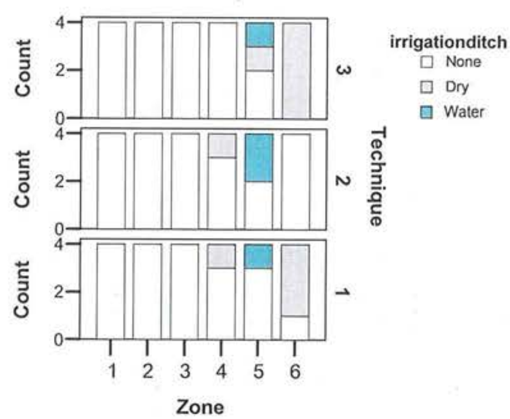

Count
Technique
1
2
3
Zone
hilllocation
None
Near
Far

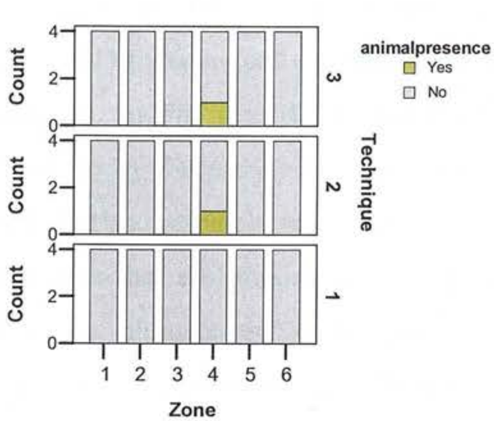

Count
Technique
1
2
3
Zone
hillcover
Undetermined
Combination

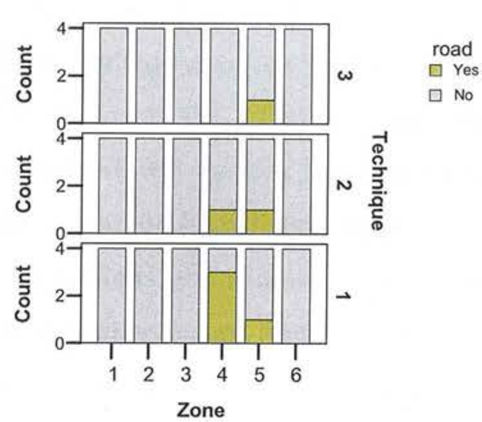

Count
Technique
1
2
3
Zone
mountains
None
One
Several


Count
Technique
1
2
3
Zone
mountainlocation
None
Near
Far


Count
Technique
1
2
3
Zone
water
Yes
No


Count
Technique
1
2
3
Zone
irrigationditch
None
Dry
Water


Count
Technique
1
2
3
Zone
animalpresence
Yes
No


Count
Technique
1
2
3
Zone
road
Yes
No

4.6. Discussion

Multiple approaches have been developed for the selection of observations intended to obtain some knowledge about a certain population (i.e. sampling). Indeed, sampling for statistical inference constitutes one of the most productive branches of statistics since 1940's (Yamane, 1967). Despite this, the sampling of scenes for being used as visual stimuli in the elicitation of people's perceptions has further been neglected. As Hull IV and Revell (1989) pointed out, there are an infinite number of scenes which could be photographed within a zone. Some researchers apply random methods for the selection of the position and the perspective from which a photograph is taken (e.g. Anderson and Schroeder, 1983; Daniel and Boster, 1976). This practice is based on the idea that a landscape has a 'physical reality' independent of people that see it (Palmer and Hoffman, 2001). However, when the photographic material is taken with the purpose to be used for getting knowledge about the perception and preferences that people have of the photographed zone, the photographs should include the 'elements' that people take into account for their perception. If the visible elements that people 'see' in the real environment are not represented in the visual material, the validity of the use of photographs might be compromised (Palmer and Hoffman, 2001; Karjalainen and Tyrvainen, 2002). For this reason, other researchers base the selection of the photographic material in public judgements or in the opinion of the researcher (Hull IV and Revell, 1989).

In lieu of further research in visual sampling, the representativeness of the photographs and its validity become assumptions of the studies of people's perception and preferences (Brown and Daniel, 1986; Kaplan *et al.*, 1972; Latimer *et al.*, 1981) independently of the methodology applied for collecting the photographic material. In this regard, the present work compares the different visible elements recorded by three methodologies. Despite the present study is an exploratory work and further research is needed for getting further knowledge about the visible elements that are important in people's perceptions, the results of this study show that the photographs taken using different approaches might record different elements of the sample zone (figure 4.3). Consequently, some questions regarding the validity of the photographic material and the replication of the studies that make use of such material can be raised. For example, how is the validity of the photographs collected by random methods if these do not ensure the representation of all relevant elements for the perceptual judgement of people? If subjective approaches are applied for the selection of the photographic material, how valid is the visual material if there are different profiles of the people's perception in the target population of interest? Moreover, how to replicate a study that use subjective approaches for the visual sampling if the criteria for the selection of photographic material might change according to the criteria of the viewer who makes the scene's selection or across the time?

Hull IV and Revell (1989) discussed some issues that affect the location of the view recorded by a photograph. First, the selection of the vantage point (the point within the zone where the camera will be located) and second, what to look at from the vantage point (the scene to be photographed). In this regard, the number of possible vantage points within a zone is infinite as well as the number of possible scenes in a specific vantage point. In the present study, the photographs were taken horizontally to eye of the viewer since this is a common practice in visual sampling for landscape assessment (Hull IV and Revell, 1989). However, the effect that the camera angle might have in the validity of the photographic material has received little attention across the literature. In this case, landscape photographs have usually been used for the representation of a zone (Shuttleworth, 1980). However, the way that a person observes the landscape depends on the objective of viewer (Canter, 1983). For instance, if the research is oriented to the study of the impact of a range management in the perception of scenic beauty by recreationists, the use of landscape photograph might be useful for the representation of the angle used by recreationists for the landscape assessment (Sanderson *et al.*, 1986). In contrast, the most useful angle of view for carrying out other tasks, e.g. the evaluation of grassland condition by local land-users, is still an open research field. The camera angle in landscape photographs reduces the possibility estimate correctly the vegetation cover of a zone (Clark and Hardegree, 2005) but when vertical photographs are taken, the representation of other elements in the landscape (e.g. sources of water) might also be reduced.

On the other hand, the results of the present work show that the characteristics of the zone might affect the composition of the visual material collected. In digital photography, the ground sample distance GSD (distance on the ground represented by a pixel) varies according to the view angle (Richards and Jia, 1999). As a result, in landscape photographs, the scene includes pixels with very low GSD (foreground) and pixels with very high GSD (background) (Clark and Hardegree, 2005). According to the topography of the study zone, if there are differences of slope in areas close to the camera, the representation of the background could be obstructed by foreground. This might cause a misleading impression of the landscape's elements by the viewer. For instance, the increase of foreground in the photographs could cause an emphasis on this element or a bad interpretation of the size of the objects in the foreground (e.g. the perception that the closer vegetation is taller compared to distant vegetation). In this regard, technique 1 did not prevent the selection of photographs with this type of error. Indeed, technique 1 gave the highest proportions of the mountain area within the photographs. This might affect the success of visual sample since the purpose was to use the photographs for a subsequent study about the human perceptions of grassland areas where the representation of paddock area is important.

Alternatively, some degree of subjective selection has been used in techniques 2 and 3. As a result, the technique 3 gave the representation of higher proportions of paddock. This suggests the relevance of the paddock representation in the perception of the people who participate in the application of this technique. In this regard, some researchers promoted participatory photography in order to include the way that people observe the environment (Hull IV and Revell, 1989). As a result, the photographs taken with participatory methods could include a major number of visual indicators applied by people in the environmental assessment (e.g. the presence of plant species used as indicators of the degree of desertification in rangelands, An *et al.*, 2007). However, the application of participatory methods for visual sampling depends on the belief that 'large groups of people share similar landscape perceptions' (Palmer and Hoffman, 2001). In that case, the representation of additional elements that might be important for other observers might be reduced. For instance, the design of rangeland evaluation guidebooks and the selection of photographs included in such guides are frequently carried out by the researchers of a particular project (e.g. Milton *et al.*, 1998; National Research Council U.S., 1962; Ottmar *et al.*, 1998; Ottmar *et al.*, 2004) but the users of such guides might be local land-users or extension advisers. If so, further research is needed in the use of these rangeland guidebooks by human groups which might not share the perception of the researcher.

4.7. Conclusions

The results presented in the present work suggest that the technique selected for collecting the visual material has critical importance for the good elaboration of the visual sample used in some environmental studies (e.g. study of the environmental perception through the use of visual questionnaires). In general, the random technique recorded less visible components representative of the objective physical characteristics of the scene than the other two techniques. Visual sample obtained by the application of technique 3 showed a closest view of the grassland characteristics within the paddock compared to the estimation of herbage yield. Further research in the application of visual sampling techniques is necessary, especially for the success of subsequent studies which involves the use of the resulting visual material.

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Chapter 5

Use of Visual Material for Eliciting Shepherds' Perceptions of Grassland in Highland Peru [♦]

5.1. Abstract

People's perceptions of their environment in high mountain rangelands ultimately affect the fragile ecosystems on which they depend, and thus their welfare. This is especially true in developing countries, where the livelihoods of people living in such ecosystems depend on grazing livestock. The present study, conducted in the central mountain region of Peru, used photographs and Q methodology to investigate the criteria and preferences that shepherds and local administrators apply in making grazing management decisions. The results showed 2 different sets of criteria and preferences. In the first set of preferences the condition of the grassland, particularly the height of the vegetation, was the main criterion. In the second set, the color of the vegetation was the key criterion. Implications are discussed for the further use of this methodology.

[♦] Cruz, M., Quiroz, R. and Herrero, M. 2007. Use of Visual Material for Eliciting Shepherds' Perceptions of Grassland in Highland Peru. Mountain Research and Development 27(2): 146-152.

5.2. Introduction

The role of human factors in sustainable agricultural production systems is fundamental (van de Fliert, 2003). People are key agents in preserving or degrading ecosystems such as rangelands. The decisions farmers and shepherds make about rangeland and grazing management contribute directly to the state of these ecosystems. These decisions are based on perceptions of the environment in which they live. As the livelihoods of rangeland inhabitants in many developing countries are based on grazing livestock, the productivity of rangeland ecosystems has a significant impact on their welfare.

Thus researchers have sought to assess the perceptions on which rangeland management decisions are based. Several methodologies (e.g. questionnaires, case studies, group interviews, aerial photography interpretations) have been used. Among these are surveys that ask participants to respond to photographs and visual representations (Swaffield and Foster, 2000). Landscape planners and environmental assessment researchers regularly use visual representation methods to assess landscape perceptions (Craik and Feimer, 1987) because they are cost-effective and easy to administer (Fairweather and Swaffield, 2001). In addition, visual representation can be used as a 'common currency' for enhancing communication among diverse groups (Orland *et al.*, 2001). In developing countries, such methods could contribute greatly to knowledge transfer in natural resource management, as well as to research on the perceptions of stakeholders.The aim of the present article, therefore, is to assess the use of visual material in a Peruvian study aiming to elicit the perceptions of primary stakeholders—shepherds and local administrators—about natural resource management in the high mountain grasslands.

5.3. Study area and participants

The study was carried out in the Sociedad Andina de Inversiones Sub-Regionales (SAIS, i.e. Andean SubRegional Investment Association) Pachacutec, in the central mountain region of Peru. The study area is predominantly natural pasture. Intensive grazing, along with the biophysical characteristics associated with such mountain regions, results in a wide variation in pasture conditions across the area. To select zones representative of the major grassland regimes, advice from researchers working in the area and from local administrators and shepherds was sought. This consultation resulted in the selection of 6 zones (Table 5.1). Herbaceous biomass production and species composition were then estimated for each zone.

Table 5.1. Zones selected for the study and total estimated dry-weights (kg/ha) of herbage per zone.

Zone	Paddock name	Production unit	Coordinates	Altitude (m)	Estimated dry-weight (kg/ha)
1	Ordemal	Santa Ana	373130 E, 8744379 N	4029	7416
2	Chicrawain	Corpacancha	367513 E, 8750699 N	4207	6736
3	Tinyac	Corpacancha	367355 E, 8748855 N	4245	6575
4	Kuspicancha	Santa Ana	371360 E, 8744317 N	4031	4473
5	Yanacocha	Corpacancha	355848 E, 8747918 N	4460	4090
6	Ranramachay	Corpacancha	361985 E, 8747228 N	4557	975

113 individuals involved in grazing management were interviewed: 76 shepherds, 15 local administrators, and 22 others. The sample comprised 68 men and 45 women. All the participants spoke Spanish and 45% also spoke Quechua, the prehispanic native Peruvian language; 97% were literate.

5.4. Materials and methods

5.4.1. Visual (photographic) questionnaire

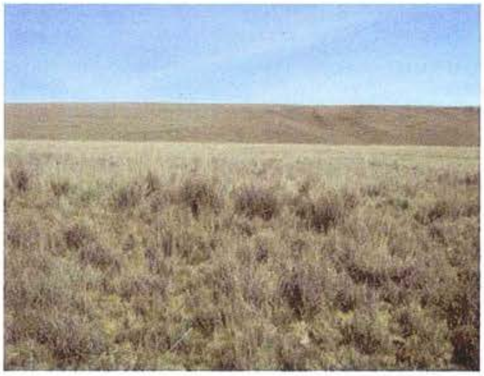
To develop the visual (ie photographic) questionnaire, 4 views of each zone from a vantage point were photographed (Figure 5.1). These points were selected by individuals identified by the community as having appropriate knowledge (eg a shepherd in charge of a paddock, or a person familiar with a zone and grazing management within it). The aim was to select vantage points from which photographs, that would represent the main features of each zone, could be taken. The 24 photographs (4 photographs in each zone) that made up the visual questionnaire were taken with a digital camera at a resolution of 1600 x 1200 pixels. At each vantage point, the direction of the first photograph was chosen at random. The other 3 photographs were then taken by rotating the camera 90°, 180° and 270° from the first (Daniel and Boster, 1976). Each of the 24 photographs (15 × 20 cm) was labeled with a random three-digit alphanumeric identifier. The questionnaire was printed on photographic paper and laminated for protection during multiple evaluations.

5.4.2. Methodology

Two methods were used to gather data. One was Q methodology, using the visual questionnaire. Q sort is a technique introduced by Stephenson (1953) for behavioral research. Participants rank order a set of items (the Q sample) under a specified condition of performance. The rank order assigned to items by each participant is called a 'Q sort' (Brown, 1980). The technique allows people to explain the basis of their choices and also allows patterns in Q sorts to be examined by factor analysis (Brown, 1980; Fairweather and Swaffield, 2001). In its most typical form, the Q sample is made up of written statements (Brown, 1980). Other authors have stressed the need to include, for example, images or recordings as sample items, but these are still rarely used. Some recent studies that combined images and Q methodology have been presented by Fairweather and Swaffield (2001), Gabr (2004), and Swaffield and Fairweather (1996).

Figure 5.1. Examples of photographs taken in the 6 selected zones.

Zone 1

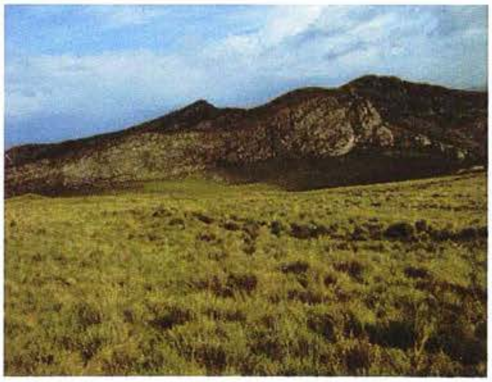


Zone 2

Zone 3

Zone 4

Zone 5



Zone 6

After a pilot test, a complete Q sort was chosen for this study. In the pilot test, participants were asked to rank the condition of grassland. The responses indicated that they were reluctant to assign low rankings, perhaps because they associated the condition of their grassland with their own performance in managing grazing. Given this, it was decided on a complete Q sort to avoid any bias.

Survey interviews using the visual questionnaire were conducted in the Corpacancha and Santa Ana production units. Participants were asked to rank order the 24 photographs according to the suitability of the area shown in the photographs for grazing sheep. To do this, the participants were first asked to rank the photographs into 6 piles (the first representing the most preferred and the sixth the least preferred). Next, they were asked to rank order the photographs within each pile according to the same criteria. How participants assessed the condition of the area and decided on the best zone for grazing sheep was left to them. The participants were merely instructed to rank order the images based on what they could see in the photographs.

The second method was a survey of perceptions gathered by semi-structured interviews. The survey was based on a questionnaire—developed with the findings from preliminary interviews with administrators and some of the shepherds—that incorporated local concepts and terminology for grazing management. Participants were interviewed and, using the questionnaire, they were asked to describe the characteristics of the grasslands they preferred for grazing sheep.

5.5. Analysis and Results

5.5.1. Q methodology

First the rank orders were analyzed for each photograph. Table 5.2 shows that the rank orders are highly dispersed, even for photographs in the same zone.

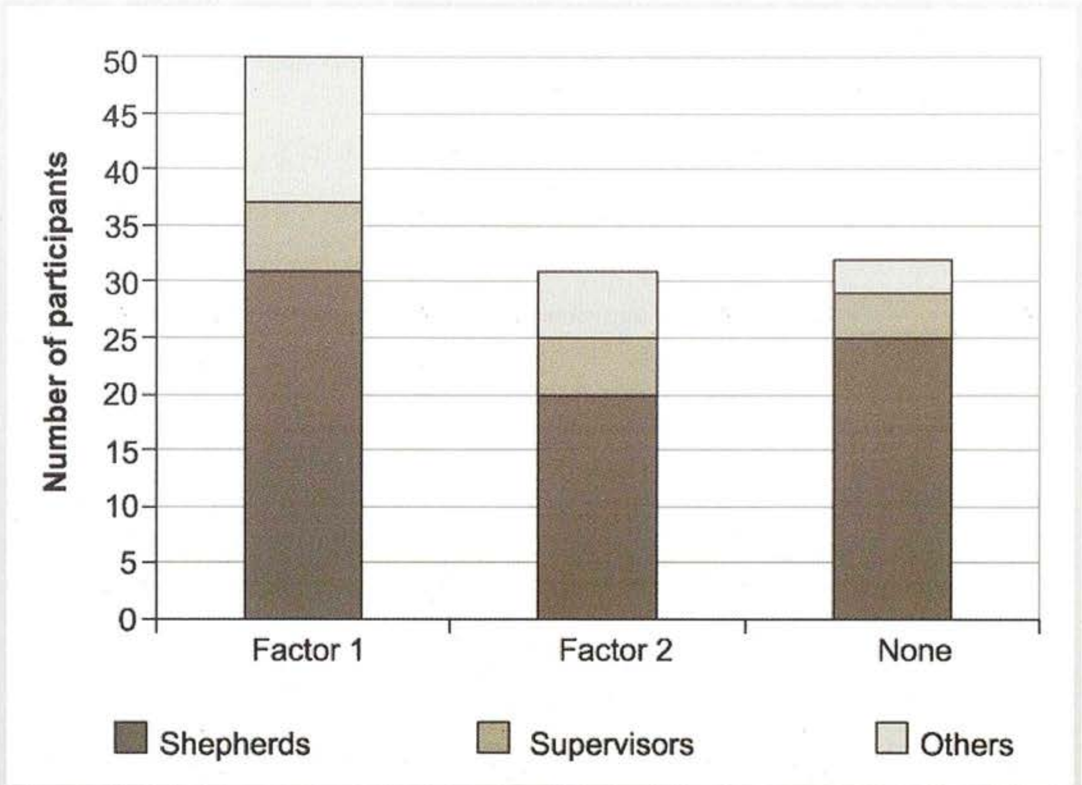
Table 5.2. Ranking of zones according to participants.

Zone	Factor 1		Factor 2	
	Median	Interquartile range	Median	Interquartile range
1	19	7	12	10
2	15	8	6	7
3	10	6	6	6
4	9	10	19	7
5	3	2	15	11
6	17	9	18	6

The 113 Q sorts were then correlated and rotated using the varimax option of factor analysis. The factors were defined according to the criterion that the loadings related to one factor had to be significant for only one factor (Fairweather and Swaffield 2001). For the Q sample in this study (24 photographs), the standard error for a zero-order loading was $1/\sqrt{N}=0.20$ (Brown, 1980). This means that the loading had to be at least $0.20 \times 2.58 = 0.52$ at the 0.01 probability level (Fairweather and Swaffield, 2001). The data at the 0.05 and 0.10 probability levels was also analyzed, but as there were no major changes in the composition of the factors, it was used the 0.01 probability level.

Two factors accounted for 53% of the cumulative variance in the rotated correlation matrix. Factor 1 accounted for 30% and Factor 2 for 23%. Q sorts contributed significantly to defining these factors in 81 subjects' responses (72% of the participants). Participants with different roles in grazing management were associated with each factor (Figure 5.2). This suggests that the profile of a participant who contributed significantly to a specific factor and shared similar preferences with the other participants contributing to that factor is not related to the person's role in the SAIS. The following interpretations are based on the 6 top- and the 6 bottom-ranked photographs for each factor (Fairweather and Swaffield, 2001).

Figure 5.2. Number of participants per pastoral function for each factor.

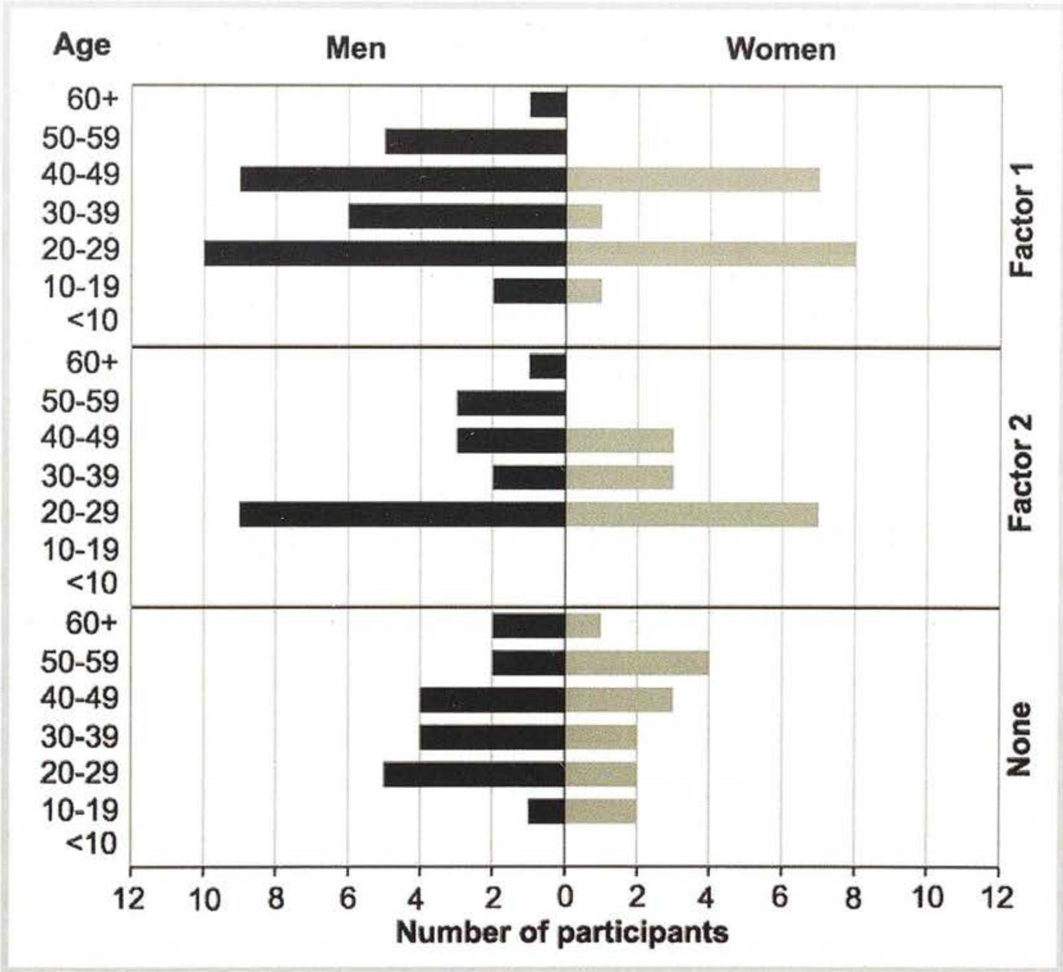


5.5.1.1. Factor 1

In the present study, 50 participants were associated with Factor 1, of whom 17 were women and 33 were men (Figure 5.3).

In the 6 top-ranked photographs in this factor, the predominant feature was the grassland in the paddock (tall grassland vegetation). The top 2 and the bottom 2 of the 6 top-ranked photographs were from Zone 1. According to the estimates of dry-weight biomass (Table 5.1), Zone 1 has the highest herbaceous biomass production of the 6 zones. However, the other 2 photographs in this factor (the third and fourth top-ranked photographs) were from Zone 6 (the zone with the lowest herbaceous biomass production). These photographs may have given a misleading impression of the vegetation in Zone 6 because of the angle and position from which they were taken with respect to the vegetation and slope of the ground. This means that visual sampling by randomly pointing the camera for the first photo may present problems in taking representative views of grassland areas. Nevertheless, the results suggest that the subjects based their preferences mainly on what they could see in the photographs rather than on any prior knowledge they might have had of the areas shown.

Figure 5.3. Number of participants for each factor by gender and age.



Of the 6 least preferred photographs for Factor 1, 4 were of Zone 5, and 2 were of Zone 4. These photographs showed areas that were not entirely grassland or, if they were, the vegetation was short and stony areas were typical.

The analysis of results for Factor 1 suggests that subjects with this set of perceptions base their grazing management decisions mainly on the height of grassland vegetation. The fact that the coordinator who led the establishment of the grazing management schedule was in the category with this factor shows that some subjects at all levels of the process shared his criterion. However, a second factor indicates that a second group of subjects did not share the same perceptions of the photographs as the subjects in Factor 1 and so did not establish their preferences in the same way.

5.5.1.2. Factor 2

The Q sorts of 31 subjects (18 men and 13 women) shaped Factor 2. The 6 top-ranked photographs for Factor 2 mainly showed open areas of grassland with short vegetation. The first, third and sixth ranking photographs in this group were taken in Zone 4, the second and fourth were taken in Zone 6, and the fifth was taken in Zone 5. Herbaceous biomass production in these zones was lower than in Zones 1 and 2. An overall green color, rather than short vegetation, was characteristic of the grassland in these 6 photographs. In addition, 2 of the 6 top-ranked photographs showed sources of water. The 6 top-ranked photographs in Factor 1 showed no water sources. The 6 bottom-ranked photographs for Factor 2 showed areas fully covered by grasslands of regular height. None of these showed sources of water and the vegetation tended to be yellow. Of the 6 least-preferred photographs, 3 were taken in Zone 3 and the other 3 were taken in Zone 2. This means that in this group, the color of the vegetation was more important to participants in assessing grassland condition and making decisions on grazing management than the height of the vegetation.

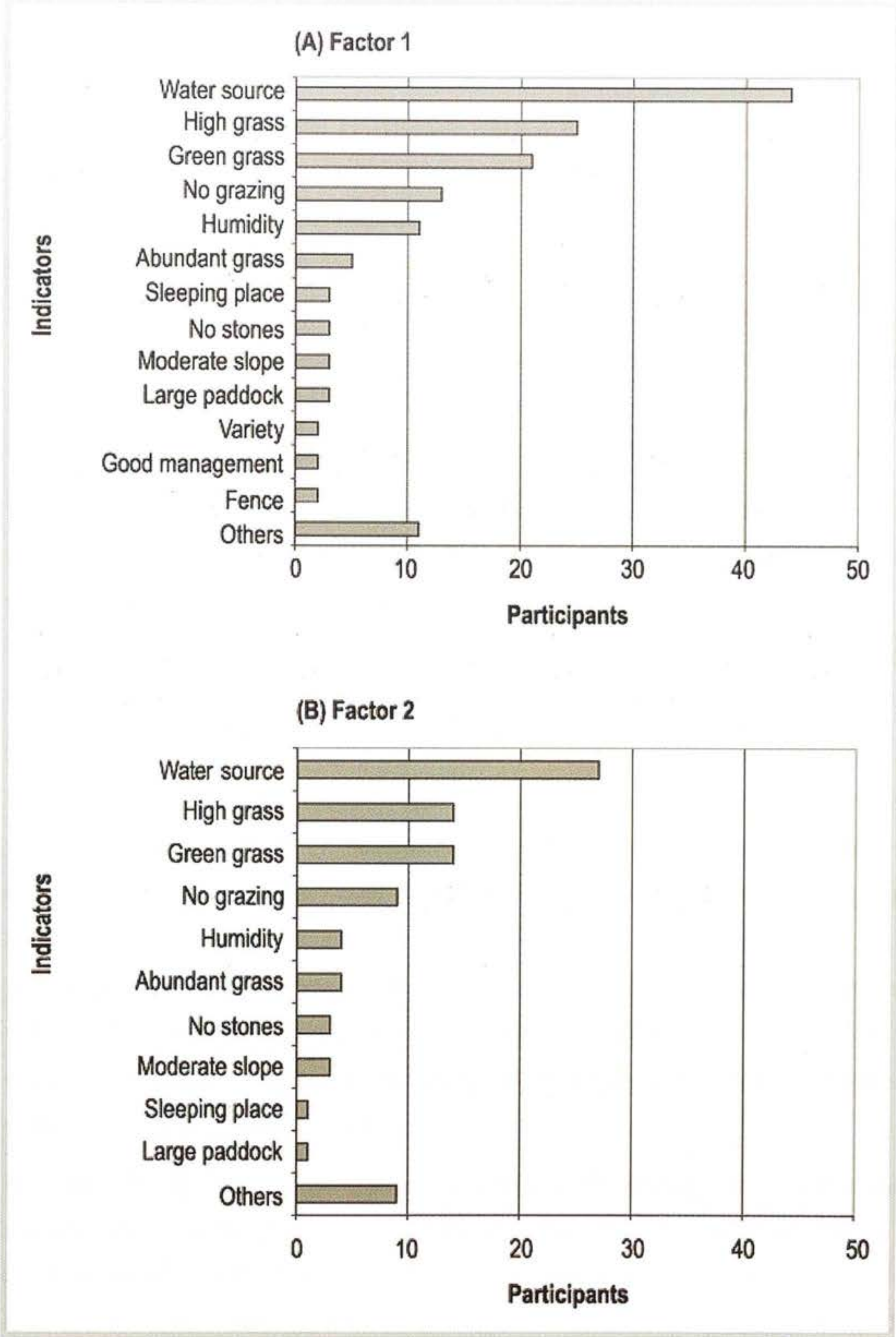
5.5.2. *Interview results*

Figure 5.4 shows grassland characteristics preferred by participants as determined by their responses to semi-structured interviews rather than to the visual questionnaire. While some of the preferred characteristics identified from the interviews were similar to the preferred characteristics identified from the visual questionnaire, there was an important difference. In interviews, subjects favoring either of the 2 factors indicated that the most important consideration in grazing management was water for livestock (lagoon, lake, river, irrigation ditch, or other large body of water). This could be because water is scarce in the study area by comparison with ecosystems at lower altitudes. In fact, the Program for the Improvement of High Andean Grasslands stresses, in its Plan of Forage Resource Management for the SAIS Pachacutec (Florez, 2003), the importance of water conservation for increasing the production of the grasslands.

Nevertheless, when the interview responses were compared to the responses to the visual questionnaire, they differed in the Factor 1 group: the responses to the visual questionnaire did not identify water for livestock as the main consideration in grazing management. Indeed, the 44% of participants contributing to Factor 1 did not rank any photographs showing a source of water among their top 6. Furthermore, the photograph with the most obvious and largest source of water (a lagoon) was classified as one of the least preferred.

Conversely, participants in the Factor 2 group had similar responses to this variable both when presented with the visual questionnaire and when interviewed. Their most preferred photographs showed sources of water (the lagoon) or some feature related to a source of water (e.g. irrigation ditches), although this was not the only criterion for their preference.

Figure 5.4. Preferred indicators mentioned by participants in the verbal questionnaire. (A) Factor 1; (B) Factor 2.



5.6. Discussion

The results of this study show that direct stakeholders (i.e. shepherds and local administrators) have different preferences when assessing grazing in this area of the Peruvian central mountains. Some researchers argue that many factors contribute to human responses to native vegetation, some of them learnt and others innate (Williams and Cary, 2001). People's preferences for certain types of grassland for grazing their livestock have been linked to factors such as their knowledge of an ecosystem or the value they assign to a grassland for agricultural production (Orland, 1988; Williams and Cary, 2001). The results of the present study suggest that inhabitants assess grasslands using visual criteria, but from different perspectives.

Previous studies have also reported that different groups have different perceptions of rangeland conditions. For example, Wezel and Haigis (2000) showed that the perceptions of men and women in Niger differ because they perform different tasks. Such task-based differences were not observed in this study. Gender, function, age, experience, and prior knowledge of the study area were not related to Factors 1 and 2.

A review of the literature indicates that this is the first study in this area to use a visual questionnaire and Q methodology to assess perceptions. The ease of application and the interest aroused among the participants by the use of photographs means that this methodology could be a powerful tool for communication, especially with shepherds. The subjects in the pilot test (a verbal structured questionnaire) responded poorly to interviews and many refused to answer questions at all. In contrast, participants responded well to the photographic questionnaire, becoming involved and participating actively.

Moreover, the Q sorts and analysis of responses to the photographic questionnaire showed clear differences in the most preferred indicators compared to the results of semi-structured interviews. Differences in responses to visual and verbal questionnaires have been reported in previous literature. Tahvanainen *et al.* (2001) used visual and verbal stimuli to compare visual perceptions with preconceptions. In the present study there may be other factors that influence the differences between responses to both types of stimulus. However, the results suggest that participants' assessments were based on what they could see in the photographs rather than on prior knowledge of the zone in question. Thus, further research is needed to validate the basis on which rangeland inhabitants make decisions on grassland management. This further research may take different approaches, such as using Geographic Information Systems and Participatory Multicriteria Decision Analysis.

In addition, concerns about the methods used to take visual samples of landscapes and the validity of visual questionnaires for perceptual research still have to be resolved. When the research objective is to compare perceptions of environments as shown in photographs with perceptions of actual environments, the method of taking visual samples of these environments is critical to the validity of the study. Previous studies suggest that visual samples must represent not only the physical components of the landscape but also the perceptual components that participants consider. The problem here, however, is how to establish these perceptual components at the outset. In this study, it was partly relied on a participatory approach; people with knowledge of the area were asked to select the vantage points for the photographs for each zone. Despite this, the study shows that participants do not base their decisions on the same criteria. It would be preferable, therefore, if the method of visual sampling used in future studies took this into consideration.

5.7. Conclusions

The results of this study suggest that photographic questionnaires and Q methodology are promising tools for research on the environmental perceptions of people whose livelihoods depend on grasslands in the Peruvian central mountains. The study identified 2 sets of criteria for assessing the suitability for grazing of natural grasslands.

The results suggest that even if grazing management plans have been developed (as is the case in the study area), stakeholders do not necessarily share the same perceptions of the best grazing areas. Further research is needed to study the implications that such differences in the perceptions of stakeholders will have for daily decisions made in grazing management, as well as in terms of the long-term impacts of such management on grassland ecosystems and the welfare of their inhabitants.

5.8. References

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Chapter 6

Discussion

White (1992) has stressed that any significant activity in natural resource management (NRM) relies to some extent on visual information. As a result, the use of visual tools seems to be a logical choice for several researchers for the improvement of communication in NRM (e.g Barrett *et al.*, 2007; Heong *et al.*, 1998; Lewis and Sheppard, 2006; Meitner *et al.*, 2005; Orland, 1992; Orland, 1994; Paar, 2006; Punia and Pandey, 2006; Sheppard, 2005; Stoltman *et al.*, 2004; Sullivan *et al.*, 1997; Tress and Tress, 2003; White, 1992; Wijekoon and Newton, 1998). However, as the literature review presented in Chapter 2 has emphasized, there are several open research questions regarding the use of visual material in NRM. Consequently, the present thesis contributes to the research on NRM giving further insight in the use of visual material in a rangeland context. The following sections contain further discussion of the results found in the present thesis, a summary of the main contributions, the list of raised conclusions and a proposal for future lines of research.

6.1. Who was the target human group of this thesis?

As it was reviewed in Chapter 2, the Agenda 21 of the United Nations Conference of Environment and Development (UNCEP) (1992) emphasises that the users and providers of information in sustainable development include stakeholders at all levels. In this regard, farmers and advisers workers who interact with them play a key role in planning and the decision making chain in agriculture (Budak *et al.*, 2005; Scherr, 1992; Solano *et al.*, 2003). In Peru, small producers and landholders constitute the vast majority of the agricultural workers (Plaza and Stromquist, 2006).

Ortiz (2006) points out that the Peruvian agricultural knowledge and the information exchange can be traced back to the prehispanic times when a 'well-organized system based on indigenous knowledge prevailed'. However, he discusses that during colonial (1532-1821) and early Republican times (beginning 1821) the indigenous knowledge systems were weaken by several changes in the agricultural sector. Nowadays, poverty is pervasive among the farm household in Peruvian rural areas (INEI, 2002). Public agricultural extension is limited and non-governmental institutions (NGOs) and private organizations try to fill the gap in the dissemination of information (Ortiz, 2006). Despite this, the scarce resources are a limitation in their work and so the prioritization of interventions and the selection of more efficient tools to target the needs of farmers are vital (Bernet *et al.*, 2001; Patanothai, 1997). As in other research areas that involves Peruvian farmers and communities (Kanashiro *et al.*, 2005), a major problem has been the lack of effective communication between researchers and land-users. The format and presentation of information is important to ensure understanding by farmers and advisers as well as to increase the participation of land users in the research. In this context, the inclusion of visual material is a common practice in the design of manuals and pamphlets (e.g. Florez, 2005; Florez and Bryant, 1989; Florez *et al.*, 1992; Torres, 2002; Valdivia *et al.*, 1997). Nevertheless, little research has been performed in the effectiveness and validity of the use of such material by Peruvian farmers and advisers. As it was discussed in Chapter 2, several claims have been made about the effectiveness of visual representations (e.g. about its validity and representativeness) in the communication with land-users but little verification of such claims is found across the literature. White (1992) have pointed out that "there is a strong future for visualization in integrated resource management. The ability to assess the impacts of various environmental management activities and promote public participation in the decision-making process is critical. The visual simulation of effects such as disease, insect damage, fire risk, transportation engineering and habitat conditions, both as related to current conditions as well as to consequences over time, are also beneficial" (page 279, White, 1992). Following this opinion, the use of visual material constitutes a promising support tool for the enhancement of a communication process among researchers, advisers and farmers in Peru. A direct effect of the findings can be found in the design of more effective guidebooks and manuals used in a rangeland context with the inclusion of more valid and representative visual material. However, the findings of this research might also contribute in the enhancement of participatory approaches commonly applied in rural areas of Peru, such as the farmer field school programs (Ortiz *et al.*, 2004), with the use of visual representations that might take into account not only the visible physical characteristics of the natural resources but also the visible elements that are important for the farmer' perceptions. Further discussion is given in the next sections.

6.2. What was the purpose of the use of photographs?

Previous studies in the use of visual representation in the context of natural resource management have tended to focus upon either technical issues, such as how to create and represent the different parts of the landscape; or upon the use of visual representation as stimulus for the study of public preferences under the background of a perception research; or upon the examination of public preferences to different proposals in the context of visual impact. Studies on the application of visual representations in the assessment of the natural resources upon the context of daily management decisions are less frequent, especially at the farmer's level.

In this regard, it was chosen to subscribe the research to the setting of a specific natural resource whose management would mainly involve daily decisions based on visual assessments. For this reason, it was selected to restrict the studies to the topic of grazing management and the concepts related to the performance of a task that involved daily decisions taken by the participants in research related to it (the condition assessment of the area for grazing management activities).

6.3. Overall response: Shepherds and advisers

The present research involved two main target human groups living in different grassland areas of Peru. Both of them were selected according to the objectives and limitations of the study.

6.3.1. Extension workers

The study carried out in Puno had the collaboration of seven participants who were identified as the advisers in the region, and whose work was related to grassland condition assessments. Even if this number of participants could be seen as reduced, it is important to note that the advisers in this area are not many, and the participants in this study were all identified advisers who were working in this topic and in the study area at the time of the research. Due to the small number of advisers and the geographic extension that they had to cover (quite large areas, but also quite common in developing countries due to lack of resources), the importance of their function as 'catalysts and information brokers' (Scherr, 1992) is recognized.

The overall response that this group showed to the use of the visual material was promising. They not only revealed interest in the use of photographs for grassland condition assessment but also some of them manifested their interest of getting knowledge of other types of visual representations. In this sense, in spite of the fact that their current use of visual material was limited at the time of the study, the overall response that this group showed to the use to this type of material was promising and they showed good disposition to the future use of visual material.

6.3.2. Shepherds

The participants in the studies carried out in the SAIS Pachacutec (chapters 4 and 5) showed also a good disposition to use visual material and to answer visual questionnaires. The study in chapter 5 showed that, compared to the pilot test, this human group showed more interest to collaborate and answer visual questionnaires than written questionnaires. However, the limitations in the field due to restricted access to computers or the continued displacement of the shepherds due to their working activities suggest that other types of visual material such as computer-based representations would not be possible to implement in the short term. Other types of visual material such as videos have been proposed in the literature (Freimund *et al.*, 2002) but the photographic material appears to be the most suitable visual material to use in the area due to its simplicity.

Campilan *et al.* (2006) pointed out that one weakness of the research that involved farmers' participation was that their response and interest in the research decreased in the course of time. On the other hand, Conroy (2005) pointed out that the use of visual material might increase the engagement of the farmer in the research. Apart from this, in a study about the cooperation of participants in surveys, Lee *et al.* (2004) concluded that the decreasing of difficulty level counterbalances the effect of increasing participation fatigue. Taking into account the cognitive advantages that the visual representations have over other types of formats (e.g. verbal and written information) (Graber, 1996; Tahvanainen *et al.*, 2001; Tufte, 1983), the findings of the case studies presented in this thesis (regarding the overall responses of farmers and advisers) (chapter 3 and 5) might contribute to confirm the proposals of Conroy (2005) and Lee *et al.*, (2004). The overall responses of both human groups in the present thesis suggest that the use of visual material in participatory approaches might attenuate the problem of 'participation fatigue' reported by Campilan *et al.* (2006).

6.4. Main findings

The particular contribution of this thesis was oriented to get further knowledge of the use of visual materials as surrogates of natural resources by local people in developing countries. The following points are suggested as the main contributions of this research:

- A comprehensive literature review of some benefits and research concerns that the use of visual representation has offered to the area of natural resource management, especially in the improvement of communication process that involves non-scientific groups.
- The evaluation of the validity and reliability of the use of visual material for the assessment of grassland conditions by extension workers. The study was done in an area where this human group has a critical role for the knowledge transfer to farmers and shepherds and where the use of visual material can contribute to the support of their work.
- The comparison of some techniques used in visual sampling, a research topic that in spite of its importance has often been neglected.
- The use of visual material for the study of the preferences that the critical stakeholders, such as shepherds and supervisors, have about their environment. This was analyzed in the context of grazing management decisions in areas where the overgrazing is linked to the degradation of the environment as well as the welfare of their local human population.

The following lines review the discussion of the main issues pertaining to the subject matter of this dissertation.

6.5. Overview

Tufte (1983), in his book "The Visual Display of Quantitative Information", presented his theory of data graphics. This paid attention to the advantages of using some types of visual representation (i.e. maps, diagrams, charts) for the communication of information over other types of data presentation (i.e. written or verbal information). Since then, several researchers have promoted graphics to help people amplify their understanding of data (Munzner, 2002). On the other hand, Lewis and Sheppard (2006) have stressed that the use of typical resource management planning, such as maps and reports with data graphics, is not necessarily the best form to present information to local communities. This is due to the fact that local communities may find these types of graphic formats difficult to understand (Lewis and Sheppard, 2006). Although several studies have been carried out in the use of some types of visual representation (e.g. the use of maps by farmers in the Peruvian Andes, Bussink, 2003), as it was reviewed in Chapter 2, the advantages of the use of photographic material are still pursued by other new technologies of visual representations (e.g. realism of the representation, Nakamae and Tadamura, 1995; Rademacher *et al.*, 2001). The literature review developed in Chapter 2 has drawn attention to the lack of research in some assumed items related to the use of photographs in NRM. Some researchers have previously stressed this fact. For instance, Palmer and Hoffman (2001) pointed out regarding the use of photographic material in landscape assessments: "As for the procedures used [the use of photographic material], the reply [of the professionals] will be that they are 'widely accepted'... Nor could they refer to work demonstrating the reliability of the evaluation methods they use, particularly as applied to their specific project." (page 151, Palmer and Hoffman, 2001). Consequently, the findings of the present thesis contribute to get further knowledge about some research areas in the use of visual material in NRM that have been neglected in the literature, especially the use of photographic material by local natural resources managers (e.g. farmers and advisers). In particular, the findings of this thesis give further insight about the reliability, validity and representativeness of photographic material presenting several case studies carried out in a rangeland context.

6.5.1. Reliability of visual material use

As it was discussed in the literature review presented in Chapter 2, reliability is one of the topics which have been identified as an area needing attention in the topic of visualization applied to environmental management (Orland, 1992; Daniel, 1992). In this regard, the case study presented in Chapter 3 explored this property in the use of photographic material by extension advisers by the calculation of the Intraclass correlation coefficients (ICCs) commonly used for measuring reliability. Reliability refers to the consistency of the scores given by a group of people in a series of assessments based on the same stimulus (Alarcon, 1991). Some researchers have previously reported the reliability of assessments based on photographic material. For instance, Hetherington *et al.* (1993), evaluating different media for representing landscapes with dynamic elements, reported high group-to-group reliabilities for the use of images (ranging from 0.91 to 0.95). In the same way, Palmer and Hoffman (2001) pointed out that in the area of landscape assessment, several researchers have also reported high reliability when photographic material is used (e.g. Daniel *et al.*, 1989; Gobster and Chenoweth, 1989; Parsons and Daniel, 1988; Rudis *et al.*, 1988). However, as Palmer and Hoffman (2001) also noted, the major part of the prior studies made use of group's mean for the calculation of reliability coefficients. That is, instead of using the individual rating as unit of analysis for the calculation of the reliability coefficient, the researchers of these studies used the group's mean rating for the evaluation of the reliability. In this regard, Robinson (1950) showed that there might be a problem when the unit of analysis is the group's mean. He showed that the correlations using a group's mean as the statistical object might be totally different to the correlations where an indivisible statistical object was used. In turn, Ebel (1951) and more recently, Palmer and Hoffman (2001) argue that if the viewers of a photograph ordinarily work individually then the individual rating should be the appropriate unit of analysis when the reliability of ratings is studied. In that case, few studies report the reliability based on the individual ratings. Palmer and Hoffman (2001) mention that the reported reliability of photographic material based on individual ratings is usually very different compared to the high reliability coefficients calculated based on group's means. For instance, Patsfall *et al.* (1984) found a reliability coefficient of 0.23 when the individual preference ratings were considered. In the same way, the data reported by Palmer (1983), Palmer (1998), Palmer and Smardon (1989) had reliability coefficients (intraclass correlation coefficients) ranging from 0.243 to 0.633 for individual ratings.

In contrast, the results of the case study in Chapter 3 showed that the photo-based assessments performed by the extension workers were highly reliable (ICCs>0.85). These results (based on the individual assessments) were even higher than the ones indicated by Palmer and Hoffman (2001) as the expected reliability coefficients among psychometricians (0.7-0.8). The difference found in this case study compared to the previous works reported by Palmer and Hoffman (2001), Palmer and Smardon (1989), Palmer (1983) and Palmer (1998) may be based on the different context were the photographs were used. The participants of the previous studies were residents of urban areas who might not have the daily experience of the environment under study as the advisers who participated in the present work. As far as the literature review allows discerning, the case study in Chapter 3 represents one of the first to assess the reliability and validity of the use of photographic material in rural areas such as the ones in the Peruvian High Plateau. These results also support the work of several researchers who promote the design of rangeland evaluation guidebooks that include photographic material (e.g. Ottmar *et al.*, 1998; Ottmar *et al.* 2004, Wright *et al.*, 2002). Findings of the case study in Chapter 3 showed that in a rangeland context, the visual materials are reliable tools for supporting the assessment of grassland condition and the stocking rate by local advisers.

6.5.2. *Validity of visual material*

The study of the validity of the visual material was proposed in two ways. The first (Chapter 3) was related to the validity according to the criterion (Alarcon, 1991). This involved the comparison of the photo-based assessments with the responses of the viewer in the correspondent real environment showed in the visual sample. The second was oriented to the validity of the contents (Alarcon, 1991) shown (Chapter 4).

6.5.2.1. Validity of the use of visual material

Other research gap reviewed in Chapter 2 was related to the validity of the use of visual material by natural resource managers. The validity is described by Palmer and Hoffman (2001) as "the degree that something is as it purports to be" (page 154, Palmer and Hoffman, 2001). In this sense, the validity of the use of visual material is usually evaluated by the comparison of the viewer's responses (e.g. visual assessment of grassland condition) based on the visual material with the observer's responses to the real environment that such visual material is intended to represent. Several authors have evaluated the validity of the use of visual material reporting high levels of consistency (high positive correlations) (e.g. Daniel and Boster, 1976; Shafer and Richards, 1974; Shuttleworth, 1980; Zube *et al.*, 1987). However, these previous studies were mainly developed on the context of landscape assessment and scenic beauty or using participants (what Blascovich *et al.*, 2002 referred as 'samples of convenience', e.g. students) who were not necessarily representative of the involved stakeholders in natural resource management. As it was pointed out in the previous section, in the case of the reliability, previous studies with human groups that were not the direct managers of natural resources reported differences in the reliability of use of visual material by extension advisers (Chapter 3). In turn, Hull and Stewart (1992) stated that "the realism of the context in which persons' responses are elicited is critical because responses (i.e. behaviors, attitudes, emotions, scenic beauty evaluations) are embedded in, and dependent upon, the physical, social, and cultural contexts in which they take place. Therefore an ecologically valid context is one that contains all factors which directly impact or indirectly mediate the observed response" (page 101, Hull and Stewart, 1992). In this regard, the case study in Chapter 3 provides further knowledge about the validity of the use of visual material in a context that was not previously reported in the literature. That is, the use of visual material by the direct stakeholders, whose daily work and economical activity is based on such visual assessments. As it was presented in Chapter 3, this case study examined the validity of the use of visual material by extension workers in the context of a task related to their daily decisions: the grassland condition assessment and the estimation of the stocking rate.

As it was mentioned in the previous section, Ebel (1951) and Palmer and Hoffman (2001) have stressed the importance of the selection of unit of analysis when visual material is evaluated. The problem found in the correlations of group's mean reported by Robinson (1950) is also a possible source of error in the studies of Daniel and Boster (1976), Shafer and Richards (1974), Shuttleworth (1980), Zube *et al.*, 1987. The latter researchers found high correlation coefficients based on the evaluation of the group's mean rating. In this regard, the findings of the case study presented in Chapter 3 showed that the use of one photograph for comparing the assessment of a complete zone (such as the one realized *in situ*) presented lower correlations coefficients than the ones observed when the ratings of the 10 photographs per zone were used. These findings might confirm the concern stressed by Ebel (1951) and Palmer and Hoffman (2001) about the use of group's means in the evaluation of validity and reliability of photographic material. Following the discussion of Hull and Steward (1992), the results based on individual photographs could suggest that only one photograph might not contain all visible factors which influence the viewer response. Findings in the case study of Chapter 3 showed that despite the experience of the participants in the assigned task, the use of one photograph produced significant differences with their performance *in situ*.

On the other hand, the use of a single photograph to represent the visual condition of a zone is a common practice (Hull IV and Revell, 1989; Palmer and Hoffman, 2001). In that case, one of the disadvantages of the use of photographs as surrogates in natural resource scenarios is that each photograph only shows a limited scene of the complete scenario under study. Moreover, the results of comparing the assessment in one photograph can vary to the assessment of another photograph taken in the same scenario but from a different viewpoint. Following this reasoning, if the objective of the use of the visual material is to serve as surrogates of real environments which are the subject under study (i.e. the research's objective is to investigate the environmental assessment of a real environment using as substitute visual material), then the use of several photographs for showing different viewpoints of the real study zone can be seen as more representative than the use of only one photograph. Alternatively, individual image could be considered when the visual material is used with other purposes (e.g. to show hypothetical scenarios by image editing).

In addition, the sub-estimation of stocking rates based on photo-based assessments showed that the validity of the use of visual material relied also on the type of task to be performed. It was observed that during in-situ assessments, the participants showed a displacement across the selected paddock for doing such assessments. Therefore, the identical assessment responses could not be expected in photo-based assessments. However, it should be noted that although significant differences were observed between in-situ and photo-based assessments when one photograph was the unit of the analysis, in general, the correlation coefficients were within what Palmer and Hoffman (2001) based on the information given by Nunnally (1978) indicated as desired targets for validity requirements: "a minimum correlation of 0.70 and a preferred correlation of 0.90" (page 155, Palmer and Hoffman, 2001).

The results about validity found in the case study of Chapter 3 might have implications in the development of visual support material (e.g. Ottmar *et al.*, 2004), which can help the adviser in the assessment of grassland assessment. Despite the ideal for a range condition assessment might be the use of an objective method, the most frequently methods applied for this task is the use of subjective methods related to visual assessments (Jordaan *et al.*, 1997). In that case, the use of rangeland guidebooks such as for example the ones designed by Ottmar *et al.* (1998), Ottmar *et al.* (2004) and Wright *et al.* (2002) make use of subjective comparisons of the visible physical characteristics showed in the photographs of previously studied areas with the zone that the extension worker is evaluating. However, little research has previously done in order to evaluate if the visual material included might provide valid representations of the zones showed in the photographs. Findings of case study in Chapter 3 indicate that the design of such rangeland evaluation guidebooks should consider the representativeness of the collected visual material and publish more than one photograph.

6.5.2.2. Validity of the photograph contents

The content validity is also related to the representativeness of the sample (i.e. visual sample). This can be determined when the visible elements which are part of the visual material constitute a representative sample of the indicators of the characteristic or performance that is under study. Hence, the content validity of the visual material is an essential requirement for the success of any use of this type of tool. However, little attention has been offered across the literature as it was discussed in the literature review in Chapter 2. Palmer and Hoffmann (2001) pointed out that when photographic material is used with the purpose to document an area, the selection of the photographs does not commonly follow any explicit approach beyond a desire to be 'representative'. As it was discussed in Chapter 4, the representativeness of visual samples for its subsequent use in environmental assessment by local human groups, involves more than one criterion. Palmer and Hoffman (2001) pointed out that "the landscape has a physical reality independent of people that can be characterized through various measurements. The landscape also has a reality that depends on our individual perceptions" (page 149, Palmer and Hoffman, 2001).

In this sense, the visual sample should include the visual elements which represent the objective physical characteristics of the study area and the perceptual characteristics which could influence the observer criteria during a visual assessment.

Due to its importance, this dissertation explored the use of three techniques applied in visual sampling which were suggested in the literature for such task. In spite of the fact that further research is needed on the efficiency of such techniques; the obtained results demonstrated significant differences among the techniques. The techniques under examination included the selection of the vantage points and the scenes to be taken according to three different approaches: a random selection, the selection of the photographs to include in the visual sample by the participant; and a selection of the vantage point by the participant and the rotation of the camera for taking the photographs in each zone.

Exploring the results, two main issues were observed when visual sampling was performed. First, the inclusion of all the physical-visible elements of the environment in just one photograph was not achieved. Second, the use of more than one photograph (four photographs per zone in that study) also presented differences in the physical-visual components recorded by the different techniques. The comparison with the estimated herbage yield of the paddock showed in the first plane of the photograph, suggested that the technique 3 (selection of the vantage point by the participant and rotation of the camera for taking 4 photographs) could be the most representative for the visible characteristics of the grasslands.

6.5.3. The use of visual material for eliciting preferences

Rangeland condition studies undertaken in Peru have dealt with different aspects of grazing management (Florez, 2003; Florez *et al.*, 1992; Wilcox, 1982). For this, different approaches have been applied but few studies are found in the human perception of the grazing resources using visual material. Although the use of visual representation in PRA has been proposed, the reliability, validity and applicability of the method (concerns discussed in studies of the use of visual representation in other areas) has not been investigated in these study areas.

The results of the study carried out in the SAIS Pachacutec (case study of Chapter 5) suggest that the use of visual material not only was suitable for working with rural human groups but that it also discriminated preference criteria among the population that other methods such as verbal questionnaires were not able to do.

Swaffield and Fairweather (1996) stated that "one of the problems with using image editing to display a range of possible options at the sub-regional level is that many stakeholders would recognise and have specific interests in particular locations" (page 217, Swaffield and Fairweather, 1996). In this study, there was explored the use of visual material for evaluating concepts related to the daily performance of the stakeholder in the management of their environment. Likewise, the research included the places that the participant was used to manage. So the 'specific interests' were also present since their absence could result in different behaviour responses to the real ones. However, the results suggest that at least one part of the population (factor 1) based their assessments in the information given by the visual material since they did not relate the visual material with the existent condition of the some real zone represented. If so, one implication of this is that the study of the preferences of local human groups can be achieved by the use of photographic material. In combination with Q methodology, the study of preferences suggest that the participants evaluated mainly the visible components of the stimulus and did not necessary refer to previous knowledge of the place, such as it was suggested by Swaffield and Fairweather (1996).

In addition, the results suggest that the assessments of such natural resource (i.e. grasslands) given by local human groups are not only based on the specific resource. The results suggest that the study of independent visual elements is not valid if it is not immersed in the landscape context. One implication for other types of visual representations is that even if it would be possible to represent the complexity of the mixture of species that take place in such ecosystems, the human experience is much more difficult to study if only one element of the landscape is shown. As Kaplan (1985) argued "Humans, after all, respond not only to the 'things', but also to their arrangement, and not merely to the arrangement, but also to the inference of what such arrangement makes possible". In this case, the use of photographs appears to provide the 'context' necessary for assessing the preferences of the local human groups.

Finally, it should be noted that although the findings of case studies presented in Chapter 3, 4 and 5 give new insight about the reliability, validity and representativeness of visual material in a rangeland context, further research is still needed in this field regarding some questions related to the use of visual material by advisers and farmers. For instance, how many photos are needed to represent a study zone in a reliable and valid way? (Daniel *et al.*, 1977; Palmer and Hoffman, 2001). How does climate variability affect the perceptions of local land-users and so the validity of visual representations across time? For instance, are the photo-based assessments given by farmers and advisers stable during and after an event of El Niño in areas such as the Peruvian High Plateau? Furthermore, how useful might be the application of visual material for measuring farmers' perceptions about climate variability? How is the validity and reliability of visual samples by different visual sampling techniques?

6.6. Conclusions

The goal of this thesis was to get further knowledge about the use of visual representation in natural resource management. For this, a review of the contributions and the concerns that the current applications of these tools have provided to the area of natural resource management were carried out. From this review, some research topics were identified of which further study was necessary in order to benefit specially stakeholders in developing countries.

Three main concerns across the literature were the subject of research in this thesis: the validity and reliability of the use of visual representation, its representativeness and its applicability in the preference research of these target human groups. The conclusions of this investigation can be summarized in the following lines:

- The study of the reliability of the assessments given by advisers showed that the estimations of grassland conditions and stoking rates were highly reliable. This was observed in the in-situ assessments as well as the photo-based assessments. These results suggest that the use of photographs can be seen as a reliable tool for such tasks.
- The analysis of the validity of the use of photographic material as surrogates of real environments showed different results depending on the unit of analysis. It was observed that lower correlation coefficients prevailed among both groups of assessments when the unit of analysis was based on the individual photograph rather than the 10 photographs taken in each zone under study.
- The use of photographic material showed to be a valid and reliable tool for the assessment of grassland condition; however, the use of only one photograph for representing the zone under evaluation must be seen with caution.

- Some visual tasks of the grazing management activities are more suitable than others for the use of photographic material as surrogates of the real environment. For instance, the estimation of stocking rate showed major differences between photo-based and in-situ assessments compared with the results of grassland condition. One reason could be the major assessment of space and distance for such tasks. Other types of visual representations could be used in these cases.
- Types of visual representations with high level of abstraction cannot be valid tools as surrogates in grassland management.
- The efficiency of the techniques for visual sampling in grassland areas requires more attention for being used in environmental studies since different techniques may result in the recording of different visible-physical components. However, the use of the mixed technique (technique 3) for visual sampling showed a closest expected scenario of the grassland characteristics within the paddock in comparison with the other two techniques under examination.
- Local human groups showed different preference patterns for assessing the grassland areas for grazing management.
- It is concluded that the methods which make use of visual representations such as photographs provide a rich source of interpretive data on farmers' preferences. However, a number of methodological concerns are recognized and have to be overcome before its use becomes more widespread practice.

6.7. Possible further work

The present dissertation has provided further knowledge about the application of visual material in natural resource management. This was done with special emphasis in its use by farmers and extension workers. These human groups represent key components of the decision making chain. In developing countries, the welfare of these groups can have the major benefits if such tools can be applied for the improvement of communication and research in rural areas.

However, the context of the study limited the development of the thesis to just one of the extensive areas that can be covered in natural resource management as well as to just one of the types of visual material that can be used. The increasing development of techniques for visual representations gives a huge number of possibilities for further applications in natural resource management oriented to the work in rural areas as well as the communication between scientist groups and non-scientists. Some of these possible future research areas are summarized in the following lines taking into account the limitations that rural areas present.

6.7.1. Comparison of the environmental perception of the researchers vs. the perception of farmers and advisers

The use of photographic material and Q-methodology showed to be a useful tool for eliciting environmental perceptions. The results in chapter 5 suggest that responses may differ when visual material or verbal questionnaires are used. Two human groups in the local population were shaped according to their criteria to assess the scenes for grazing management. The subsequent use of the visual questionnaires could let us know if scientists who work in the topic share similar perceptions or if they see and assess the environment in a different way. If so, it would be interesting to know the clues that guide such differences and examine its possible consequences.

6.7.2. *Comparison among other types of visual representation*

The use of photographic material has shown to be a valid method to assess grassland condition. However, other types of visual representation might outperform the tool used in the present research. A cost-benefit of the use of other technologies should be achieved in order to make a better decision in the choice of the type of visual material.

6.7.3. *Decision support systems*

Across the literature, there is a continuous discussion about how feasible is the adoption of decision making systems and the low degree of utilization by managers such as advisers, farmers and growers in agricultural practice (Leeuwis, 1993; McCown, 2002; Woods *et al.*, 1993). In Chapter 2, it was indicated that one of the proposals for improving such degree of adoption is the development of user-friendly systems (e.g. linked to visual representations). However, in developing countries, the lack of a computer knowledge base among the rural people is one of the strongest problems that the implementation of such technology faces. Furthermore, even if the use of computers would increase in the agricultural community (Parker and Sinclair, 2001), the results of the present research suggest that more than the only access to computer base is needed for achieving such goal.

A data-driven representation should to be examined in the light of the results presented in this dissertation. A direct implementation of such interface may be difficult to achieve due to the output type of several decision support systems in this topic. Moreover, the validity of the contents could be difficult to examine due to the visual complexity of the landscape. Nevertheless, the orientation of the development of decision support systems that not only take into account the physical characteristics of the ecosystem but also the perceptual characteristics of the final user might give interesting results. Further research must be done in this aspect.

6.7.4. Virtual laboratories

Virtual environments have been proposed as research tools for environmental psychology (de Kort *et al.*, 2003). In spite of the actual limitations for their implementation and use by direct stakeholders, the possible benefits in the study of environmental perception suggest that the development of such tool could have an interesting application in the study of visual clues under controlled environments. However, the necessary realism of the representation according to the results of chapter 3 should be considered as well as the perceptual visible characteristics discussed in this research. The results of this research suggest that the development of such visual tools might consider the user-centre design approach (i.e. direct to advisers or farmers) and the research of visible elements that are taken account by the stakeholders.

6.7.5. Support for advisers through the use of visual representation

In spite of the fact that the development of visual material as support material for the assessment of visual properties of the natural resources is frequently used, the results of this dissertation suggest that more attention have to be given to the representativeness of such visual material and the subsequent use by advisers. Two main lines of research can guide the course in this topic. Firstly, the characteristics of the visual material and the validity of the contents that it intends to represent. As it was discussed, most visual material is based on one photograph according to the research criterion. However, the study of the representativeness of such scenes (e.g. at a landscape level), is not a frequent practice.

Secondly, the performance of the use of such visual material by the users should be examined. As the results in this dissertation suggest, the visual assessments of advisers depending on the task to realize, could vary in degree of efficiency; not only due to the characteristics of the participant but also due to the characteristics of the applied visual material.

6.8. References

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